

**IDENTIFYING AND ELIMINATING THE
ROOT CAUSES OF THE UNDESIRABLE
EFFECTS PRESENT IN SMALL
MANUFACTURING BUSINESS
PRODUCTION SYSTEMS**

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September 1999

Submitted to the University of Cape Town in partial fulfillment for the degree of
Master in Engineering Management

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ACKNOWLEDGEMENTS:

I wish to thank all the survey questionnaire respondents for taking time out from running their businesses to answer the questionnaire. I would also like to thank my supervisor, Gordon Lister for his support and guidance.

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ABSTRACT:

The manufacturing industry in South Africa is presently experiencing severe competition from cheap imports from the east. Furthermore, the present high interest rate and newly legislated business and labour laws have created unfavorable conditions for small manufacturing businesses. For small manufacturing businesses to survive in this competitive market and under unfavorable conditions, they require increased performance in lead times, product innovation, product and service quality, manufacturing flexibility and responsiveness and, reduced manufacturing costs.

To attain sustainable improvements requires a comprehensive understanding of problematic situations present in small business manufacturing systems.

The aim of this project was to identify the major problems present in small business manufacturing systems, to highlight the difference between, and show the causality relationships between, “symptoms” of problems and their root causes, and to propose ways of eliminating the problems.

The first three tools of the Theory of Constraints thinking process, the current reality tree, the conflict resolution diagram (or evaporating cloud) and the future reality tree, were used to answer the question - what needs to be changed and what must it be changed to in order to achieve long-term sustainable improvements to the performance of small manufacturing business manufacturing systems?

The “symptoms” of problems, referred to as undesirable effects (UDEs), were identified through four years of experience in managing a small business manufacturing system, through discussions with managers of other small manufacturing businesses, through the literature reviewed and through the use of a survey questionnaire form that was mailed to a sample of small manufacturing businesses. A Current Reality Tree was then constructed indicating the causality relationships between possible causes and their resulting undesirable effects. Conflict Resolution Diagrams were then used to define the

problems precisely and to generate new injections (conditions or actions), followed by the construction of a Future Reality Tree, which was used to verify the causality relationship between the proposed injections and the desirable effects. The necessary conditions and actions for eliminating the fundamental problems were provided in an action plan, which was based on the final Theory of Constraints thinking process tools – the Prerequisite Tree (Intermediate Objectives Map) and the Transition Tree.

The main conclusions drawn were as follows.

1. The limited resources available to small manufacturing businesses are in most instances ineffectively and inefficiently utilised. The actuality (the current achievement with existing resources and constraints) of the small business is considerably lower than its capability (the possible achievement using existing resources within the existing constraints) and its potentiality (what could be achieved by developing resources and removing constraints).
2. The effect-cause methodology of the current reality tree is useful in identifying the causes of effects, the high leverage points in the system where the greatest achievements could be obtained with the least effort and resources. Furthermore, the current reality tree showed that root causes are far away in distance and time and seemingly disconnected from their effects.
3. The root causes identified were as follows.

Root cause 1. Production managers lack the knowledge and skills that they require to effectively and efficiently manage their manufacturing systems.

Root cause 2. Production managers do not understand the principles of systems thinking and its use in problem solving and managing their manufacturing systems. Production managers believe that optimising every element within the system will result in optimised system output.

Root cause 3. Production managers have extremely set and narrow mental models (paradigms) on how their manufacturing systems should be managed. This results in resistance to change and in the “do as you are told” attitude towards workers.

Root cause 4. There is limited management staff in small businesses. This means that production managers cannot focus on manufacturing related management details as they have to cover a variety of other business activities, such as, marketing the business's goods, managing the business's finance and performing the general administration activities of the business.

Root cause 5. Lending institutions require unreasonable security and offer unreasonable lending rates for finance. This, combined with excessive money tied up in the manufacturing system results in a lack of working capital.

4. Initiating and sustaining a continuous improvement program requires additional time, money, knowledge and skills. These five root causes however, make it extremely difficult for production managers to make effective changes.

The main recommendations made were as follows.

1. Small business production managers must be assisted by outside sources that offer affordable and easily available assistance in managing and improving small manufacturing businesses. The following type of partnerships/organisations should be formed to assist small businesses.
 - Small manufacturing business partnerships that are made up of similar small manufacturing businesses that share information, management and technology.
 - A government and business assisted organisation that provides affordable assistance in managing and improving small businesses.
 - Small business and tertiary education institutions (universities, technikons, technical colleges) partnerships where students assist small businesses in all management functions as part of their education.
2. Finally, it is recommended that further research be carried out on the formation of these business partnerships and assistance organisations.

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1 INTRODUCTION:

1.1 Aim and Objectives:

The aim of this research project was to explore the underlying structure responsible for the behaviour of manufacturing systems of small businesses, defined in 1.2.2 Limitations and Scope of Research, in order that solutions may be formulated to eliminate constraints to manufacturing system performance.

The greatest potential advantage of small manufacturing businesses over large ones is their ability to make decisions and react immediately without the formal procedures of bureaucracy. This can result in highly flexible and adaptable manufacturing systems that are able to service customers efficiently. With the restructuring of large organisations and the continual improvements being made to the performance of their manufacturing systems, it is essential that small businesses improve their manufacturing system performance to remain competitive.

Improving manufacturing system performance can only be achieved by removing the problems that limit its performance. In many small businesses however, problems are never effectively identified and eliminated. Undesirable effects (the symptoms indicating that problems exist) present in small business manufacturing systems are managed, instead of their root causes being eliminated. This results in short-term performance improvements with no long-term improvements. To effectively improve manufacturing performance, and subsequently overall business performance, a full understanding of the problems associated with managing the manufacturing systems of small businesses must be gained.

The objectives of this research project were therefore to,

- 1) Identify the common undesirable effects occurring in manufacturing systems of small manufacturing businesses.
- 2) Determine the root cause or causes of the undesirable effects identified.

- 3) Show how the undesirable effects/root causes constrain the performance of these manufacturing systems
- 4) Recommend solutions for eliminating root causes in manufacturing systems of small businesses.

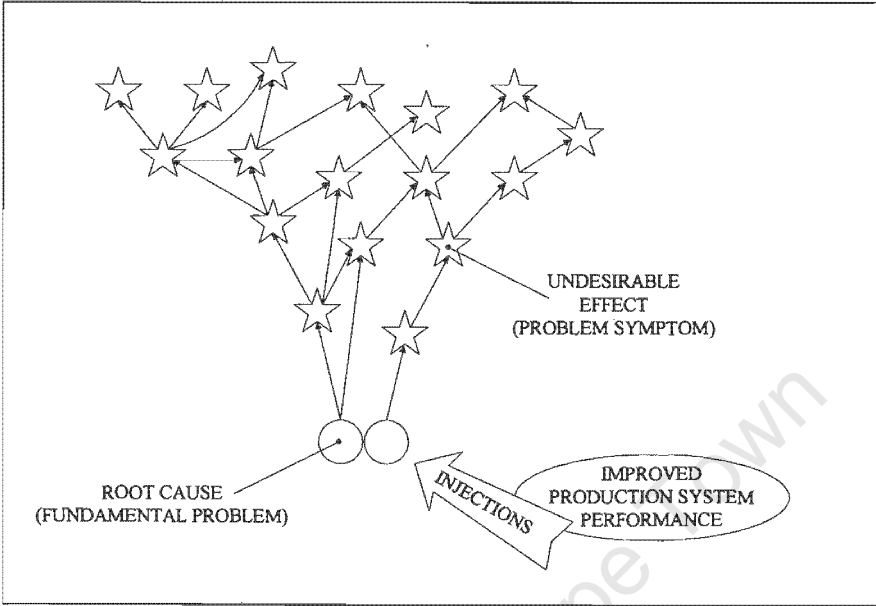


Figure 1 :Thesis Objectives.

1.2 Assumptions and Limitations:

1.2.1 Assumptions:

The primary assumption of this thesis is that all or most of the undesirable effects present in manufacturing systems of small businesses have a few common underlying root causes.

1.2.2 Limitations and Scope of Research:

The scope of the dissertation has been limited to, and is relevant to, the manufacturing aspects of small businesses conforming to the following conditions.

Businesses with,

- a physical value-adding transformation process from inputs into outputs
- between 5 and 70 persons employed in the manufacturing system of the business
- less than 10 persons managing and administering the business
- production facilities situated in the Western Cape region
- turnover of more than R150,000.00 per annum
- mostly labour intensive manufacturing processes and operations
- no association with other organisations
- production flow of either batch type or a combination of batch type and job type production flow.

Furthermore, the research conducted for this project was concerned with businesses that were up and running or in “*steady state*”, Chase & Aquilano [1]. The focus of the research was therefore limited to:

- Day to day activities of operations management,
- Improving system performance, and
- Revising the business system in a changing environment.

Although other aspects of small manufacturing businesses, including, sales, marketing, finance, etc were not thoroughly covered, they have been considered, and do interact with the manufacturing system and must therefore be considered in any attempt at utilising the information generated and recommendations made.

2 THE NATURE AND CHARACTERISTICS OF SMALL BUSINESSES:

Cronje, Hugo, Neuland and Van Reenen [2] states that there is no generally accepted standard definition of what constitutes a small business presently in South Africa. For the purposes of this research project the definition of a small manufacturing business has been defined in the previous section, 1.2.2 Assumptions and Limitations.

Chase and Aquilano [3] point out that although there are fewer activities performed in small businesses than are performed in big businesses the same basic business functions such as, sales and marketing, finance, operations and production, human resources, purchasing, distribution, research and development, must be covered. The relatively small number of activities and tasks means that unlike large organisations, small businesses cannot take advantage of economies of scale, not only in purchasing supplies and raw materials but also in the workforce, production scheduling, management systems and in selling and marketing.

The limited number of management and administrative staff must cover all the business's functions, activities and tasks where, in many instances, one person must perform the tasks of more than one specific business function. For example, the owner of a small business may perform all the necessary tasks of managing and overseeing the manufacturing system as well as having to perform all the necessary financial and accounting tasks.

Cronje, Hugo, Neuland and Van Reenen [4] believed that performing multiple tasks, as well as making decisions for these varying functions on both a strategic and operational level results in two major problems, the first being the lack of management focus and the second the lack of management expertise in each of the various functions to be covered.

The lack of management focus and the lack of management expertise both result in limited alternatives in management decision making. Decisions are usually based on insufficient information and on subjective approaches, for example, on past experience, on personal preference or on intuition. These approaches may be advantageous in having

a creative, innovative and responsive business environment but lead to poor decision making and subsequently ineffective and inefficient management. Improvements that are made are short-term local improvements and are usually only temporary.

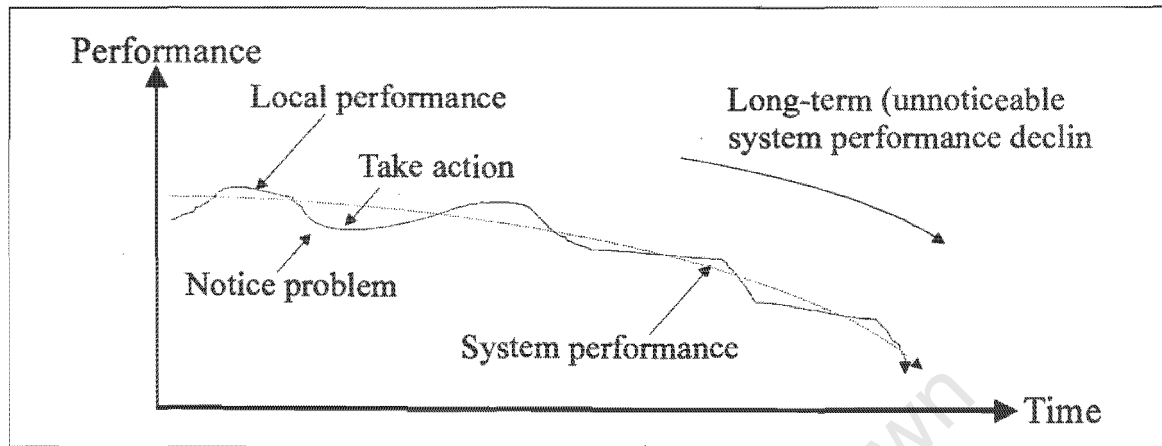


Figure 2: The Effect of Ineffective and Inefficient Management Decision-Making

3 THE NATURE AND THEORY OF RESEARCH:

Jill and Johnson [5] point out that the objective of carrying out research is to explain and to understand certain events, behaviour, phenomena or relationships that occur in nature in order to answer the question “why or how do certain things happen?” for either recording purposes or for basing a decision upon. The research process is therefore a process of learning or conversely, the process of learning is the quest for understanding.

Carrying out research on a particular subject is a complex and difficult sequence of activities. The process is like most other activities, theory dependent. Jill and Johnson [6] define a theory as a network or combination of hypotheses that presents the causal relationships between two or more abstract concepts in a way that attempts to explain natural or social phenomena. For example, “reducing the batch size leads to an improved balanced workflow through the manufacturing system” is a hypothesis that explains and predicts how batch size effects workflow through a manufacturing system. “Reducing the batch size” and “improved balanced workflow” are the concepts of the theory and “leads to” is the causal relationship between them. The example can be reduced to the simplest theory structure,

A causes, or leads to B.

Or conversely,

B is the result of A.

In natural and social environments however, nothing is this simple. Various hypotheses may be linked together to form a more complex theory or prerequisite conditions may have to be in place for the theory’s causal relationship between the concepts to occur.

Most learning begins with an experience, a stimulus, or an observed event or with an existing theory constructed by others. In the first instance an event or stimulus is experienced or observed which is then reflected upon with further observations made in order to make sense of the initial experience or observation. Attempting to make sense of the experience or observation leads to the development of explanations in the form of

abstract rules or principles that can be applied to new events or stimuli similar to those already experienced or observed. In this way a theory is constructed. Testing the new theory results in new experiences that present new events or stimuli to reflect upon, observe, and explain.

In the second instance a set of abstract rules or principles are acquired from literature or from other sources on the subject under investigation. These abstract rules or principles are applied to a physical situation in nature and their validity tested. Testing the theory generates new experiences that in turn present new stimuli or events to reflect upon, observe and explain. These two processes are shown in Figure 3: Kolb's [7] Experiential Learning Cycle, which shows the four stages of learning.

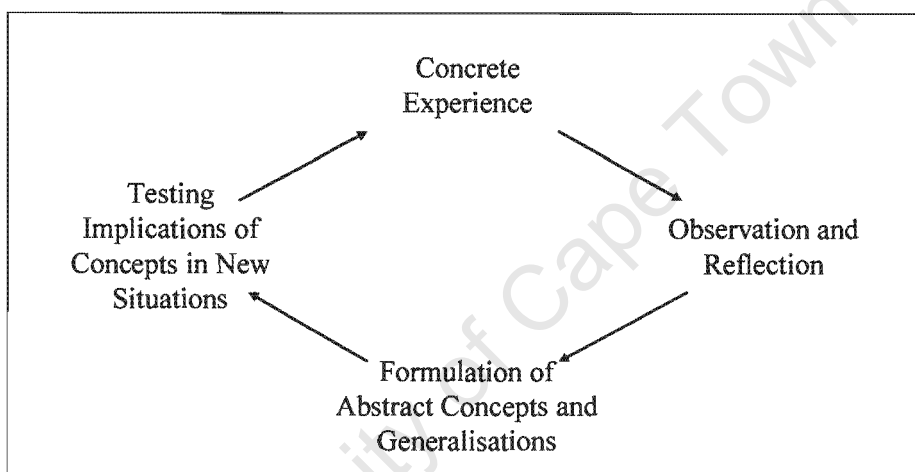


Figure 4: Kolb's [8] Experiential Learning Cycle

In the case of the thesis research project which is a learning exercise, constructing a general theory, hypothesis or model for evaluating and testing or evaluating and testing an existing theory, hypothesis or model, forms the basic structure of the project's research process.

Jill and Johnson [9] state that there are two "scientific" approaches to research, the deductive approach and the inductive approach. According to Kolb's experiential learning cycle, deduction corresponds to the left-hand side of the cycle while the inductive approach corresponds to the right-hand side. Using either of these approaches depends on the nature of the research to be carried out as well as on the subject matter.

While the outcome of deduction is observation, the outcome of induction is theory as it involves reflection upon past experiences in order to generate explanations and generalisations from those experiences that make predicting future experience possible.

The nature of the research problem presented in this project required the use of the inductive approach to the research as it involved observing the real world, reflecting on the observations made and developing a hypothesis, theory or representative model based on the observations and reflections. Figure 5: The Process of Induction shows the process of induction as well as its place in Kolb's Experiential Learning Cycle.

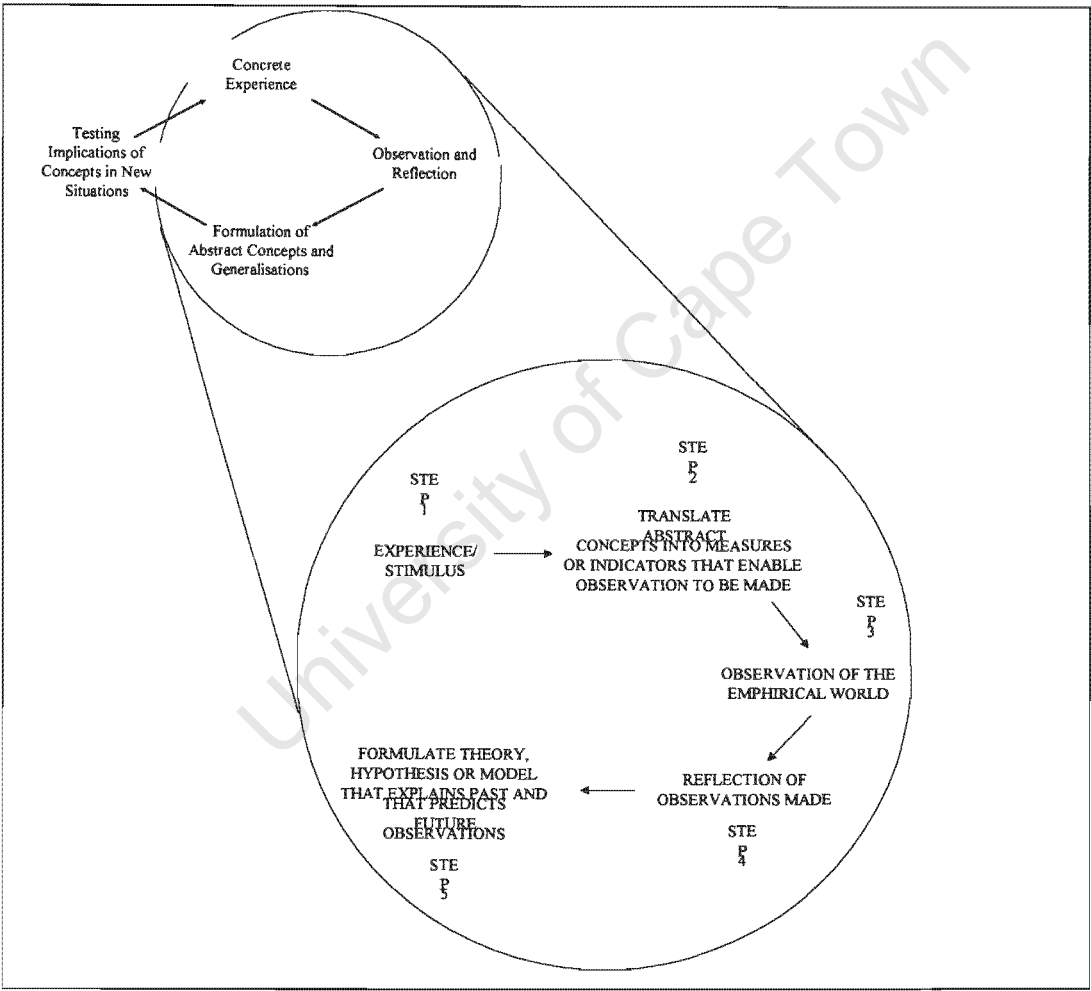


Figure 5: The Process of Induction

3.1 The Research Process:

Figure 6: Research Methodology, below, shows the basic process of the research carried out for this research project.

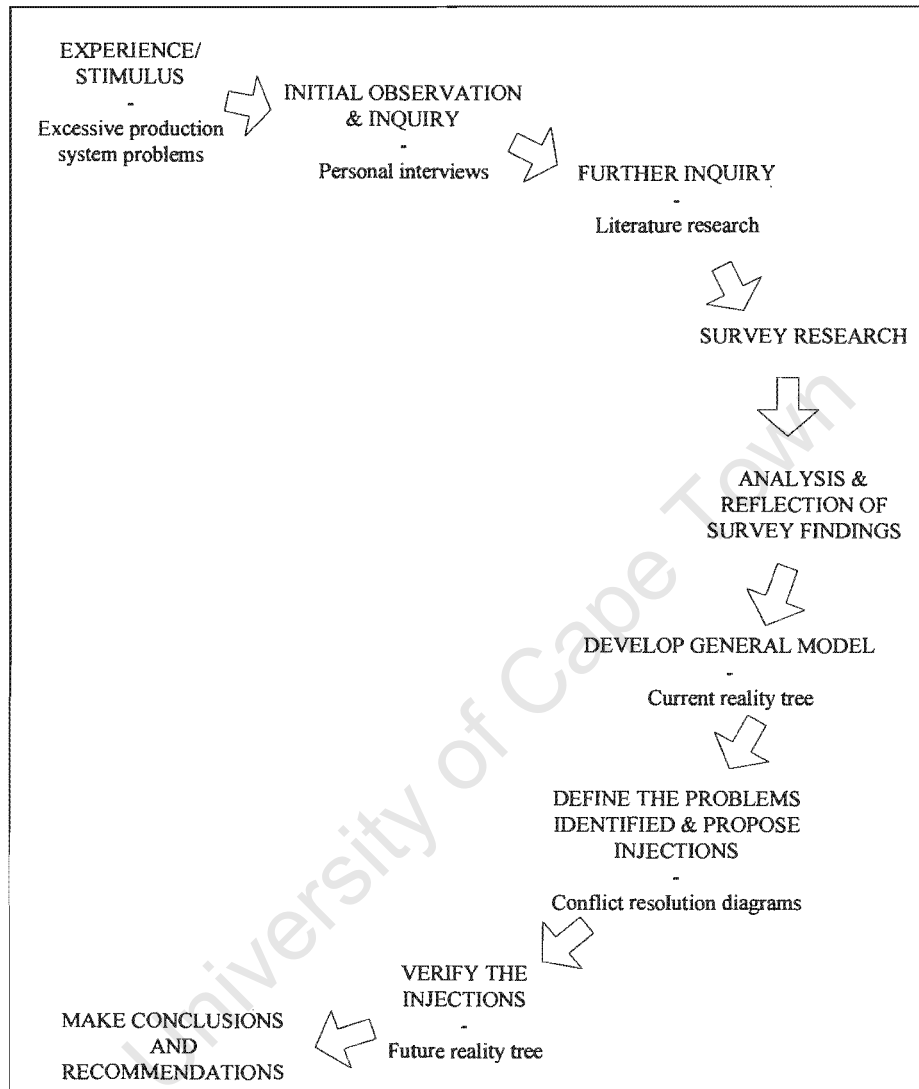


Figure 6: Research Methodology

The research process followed the process of induction discussed earlier as,
stimulus – observation - reflection – theory formulation.

The research process began with a stimulus, which was the personal experience of constantly dealing with the same problems in the daily management of a small business's manufacturing system with no long-term performance improvements being achieved.

The first step in achieving the aim of the research project, understanding and explaining the stimulus, was to validate the research by ensuring that the problem was not exclusive to only one business but that other production managers of small businesses had the same or similar problems. This was done through discussions with four production managers, three of whom were owners or partners in their businesses.

The next step in the research process was to review the work done by others on the research problem and to determine the effectiveness of using the related literature for understanding and improving small business manufacturing performance. The literature research included two major topics besides that of small business management. The first was survey research design and methodology and the second, systems thinking and the theory of constraints. These research tools were later used to determine the undesirable effects and root causes, and to develop a model that showed the relationships between them.

The next major stage in the research process was collecting the data required for developing the model. This was done through the use of a survey. In terms of the process of induction the survey was the means of observing and recording the real world. The data generated by the survey was analysed and the major findings are presented.

The next major stage in the research process was to develop and construct a representative model, a current reality tree that showed the relationships between undesirable effects and their causes. The current reality tree and the conflict resolution diagrams were then used to identify the areas with most leverage in problem solving. The future reality tree was then constructed and used to verify the relationship between the proposed injections and the desirable effects.

The final stage of the research process was to draw conclusions from the research and to recommend a set of guidelines for small business managers for improving the performance of their manufacturing systems.

4 LITERATURE REVIEW:

Problems associated with managing small businesses, described in section 2, The Nature and Characteristics of Small Businesses, were identified from observations made over 4 years of experience in the field of production management in a small business, and from regular discussions with other production managers of similar businesses.

The review of the relevant literature was aimed at gaining a fuller understanding of the dynamics of these problems, at identifying other possible major problems, to determine the effectiveness of other peoples work on the same subject and to develop a means of achieving the aim of the research project.

The difficulties of managing the small business:

In “The Decade Ahead” from “Managing the Smaller Company”, Herrmann [10] introduced the major challenge of large organisations as well as small businesses by describing the rate of change of today’s economy as at “*roller coaster pace*”, which he felt may be too swift for many small businesses. Herrmann pointed out that, although the number of small businesses was growing at about the same rate as larger organisations, the components of small manufacturing businesses within the entire small business community was shrinking, as more small businesses moved away from the complexities and tougher competition associated with manufacturing, toward service related business. In the introduction to “Growing Concerns – Building and Managing the Smaller Business”, Grumpert [11] also mentioned the trend of businesses moving from manufacturing to service related businesses. Grumpert, however, pointed out that the major reason for this shift, especially with small businesses, was that service related businesses did not require expensive equipment and did not have to carry inventory.

One of the major problems associated with managing small business manufacturing systems described by Herman, was the ineffective management of the operational details of small businesses. This problem was mentioned in two other works reviewed, in

“Introduction to Business Management”, by G J de Cronje, E W Neuland, W M Hugo and M J Van Reenen [12], and in A Bowen and D Bristow - Bovey’s [13] article “The Small Manufacturer”.

Although “Introduction to Business Management” was not primarily a book on small business management, it included a short section that briefly characterised small businesses, described some of their problems and most importantly, highlighted the importance of managing a small business according to its characteristics and resources and not as a scaled down version of a large organisation. Grumpert mentioned this common misconception amongst small business managers in his statement, *“Successfully running a small business is not simply a matter of adapting principles developed over the years in the areas of finance, marketing, organisational behaviour, and production-manufacturing and applying them on a smaller scale.”*

In their article, “The Small Manufacturer”, Bowen and Bristow - Bovey mentioned briefly the main causes of small business failures presented in Kaplan’s “Small business: Its Place and Problems”, which included the reverse of Herrmann’s cause, the preoccupation with business details. In this case the management of strategic details were ignored and had the same effect - gradual business demise.

In “Manufacturing Problems and Objectives” from “Managing the Smaller Company”, Markle [14] briefly discussed problem solving methodology. He mentioned the importance of defining a problem but did not provide a methodology on how to define a problem. The example that Markle mentioned, ‘a new product line or a piece of equipment that does not function as intended’ and ‘an operation that was going well and suddenly turned sour’ are however, not problems but undesirable effects or symptoms indicating that problems exist. Markle pointed out that, *“although many manufacturing problems in small companies are similar to those in large ones, it is likely that the manufacturing manager of the small company will have fewer human resources available to him for help with these problems”,* and that, *“the smaller firm simply does not have the financial latitude of the industrial giant.”*

Using the systems approach rather than non-systems approach to problem solving:

In his book “The Fifth Discipline - The Art and Practice of the Learning Organisation”, Senge [15] described the systems thinking approach to problem solving and discussed the importance of using this approach as opposed to a non-systems thinking approach. Senge presented ‘*The laws of the fifth discipline*’ which showed the negative effects on system performance of using a non-systems approach to problem solving.

Senge pointed out that the major strength of the systems thinking approach was that when the system as a whole is considered, the area of greatest leverage can be identified. This is especially important in small businesses where the extremely limited resources must be efficiently used.

In their work “Total Systems Intervention”, Flood and Jackson [16] discussed the difference between the systemic way of thinking and the reductionist way of thinking (non-systems way of thinking). They focussed on system ideas that were directly relevant to the practical concerns of managers, decision-makers and problem solvers in organisations.

These two works however, did not provide practical and specific methods of using systems thinking in management problem solving and decision making.

The Theory of Constraints - a systems thinking approach to performance improvement:

In “The Goal” Goldratt [17] described two basic phenomena of production systems, dependant events and statistical fluctuation, and discussed how they interact and combine to make managing a manufacturing system a complex and difficult task. Goldratt introduced his theory of constraints and showed how it could be used to deal with the phenomena for improved manufacturing system performance.

In “What is This Thing Called Theory of Constraints and How Should it be Implemented” Goldratt [18] presented and explained the thinking process that generated the “*generic-methods*” and underlying assumptions in “The Goal” and “The Race”. Goldratt introduced and discussed the two major components of the theory of constraints. The first, the thinking process that enables decision-makers to uncover and identify “*core problems*” and to “*invent simple solutions*” to eliminate these problems, and the second, how to implement the solutions by using “*psychological aspects*” to assist those who are affected. In his discussion on the TOC thinking process, Goldratt introduced the effect-cause-effect methodology for determining “*what to change?*”, the first step in the process of ongoing improvement.

In “Quality and the Theory of Constraints”, H. William Dettmer [19] discussed the theory of constraints, focusing on the various types of constraints, both physical and policy, that limit the performance of production systems. Dettmer showed that Goldratt’s thinking process is an extension of systems thinking and discussed the pitfalls of traditional analytical thinking. Dettmer showed how policy constraints cause most physical constraints through the use of an example, thereby highlighting the necessity of searching for policy constraints in any attempt to finding root causes.

Taking a logical step-by-step approach to performance improvement.

In an article, “Clouds and Trees and Flying Pigs”, taken from his newsletter “TOC Strategies”, Tony Rizzo [20] briefly described the theory of constraints thinking process tools, the current reality tree, the future reality tree, the evaporating cloud or conflict resolution diagram, the prerequisite tree and the transition tree, all of which are derivatives of Goldratt’s basic effect-cause-effect methodology.

In another article, “An Introduction to the Theory of Constraints Thinking Process”, Dettmer [21], reiterated the importance of identifying the policy constraints that have far more influence over the systems success than physical constraints. Like Rizzo, Dettmer introduced the 5 thinking process tools, described their usefulness and briefly mentioned

'The categories of legitimate reservation' which are a set of logical rules governing cause and effect relationships.

Dettmer [22] explained why the current reality tree is so important in the thinking process and prescribed a number of methods for constructing logically sound trees in "Realising Quantum Improvements in CRT Quality".

In the article, "Profit Improvement Through Production Lead-Time Reduction - A Theory of Constraints Case Study", Wright [23] and his co-authors presented an example of how the theory of constraints, particularly the three principle steps required for a process of ongoing improvement - "what to change?", "what to change to?" and "how to cause the change?", was applied to a knitwear company. Wright and his co-authors discussed the usefulness of the TOC thinking process for developing logical and systemic thinking skills for production managers. The detailed step by step presentation of how the root cause of poor due-date performance, an undesirable effect, was based on the process described in Goldratt's "What is this thing called theory of constraints and how should it be implemented". Wright's article described a practical example and was therefore, simpler to understand and follow.

In his work, "Goldratt's Theory of Constraints – A systems Approach to Continuous Improvement", W.H. Dettmer [24] gave a detailed description on each of these five thinking process tools, explained the mechanics of these tools and provided a detailed step-by-step approach to building these trees.

The key areas to performance improvement:

Like Goldratt, Iwao Kobayashi [25], the director of the PPORF Development Institute, believed that *"A revolution is not accomplished in one step"*. In his work, "20 Keys to Workplace Improvement", Kobayashi described a systematic step by step approach to improving productivity performance. Kobayashi outlined the 20 key areas, which if improved using a step by step approach could lead to productivity improvement. Figure

7: Kobayashi's 20 Key Improvement Areas shows these areas as well as the relationships between them.

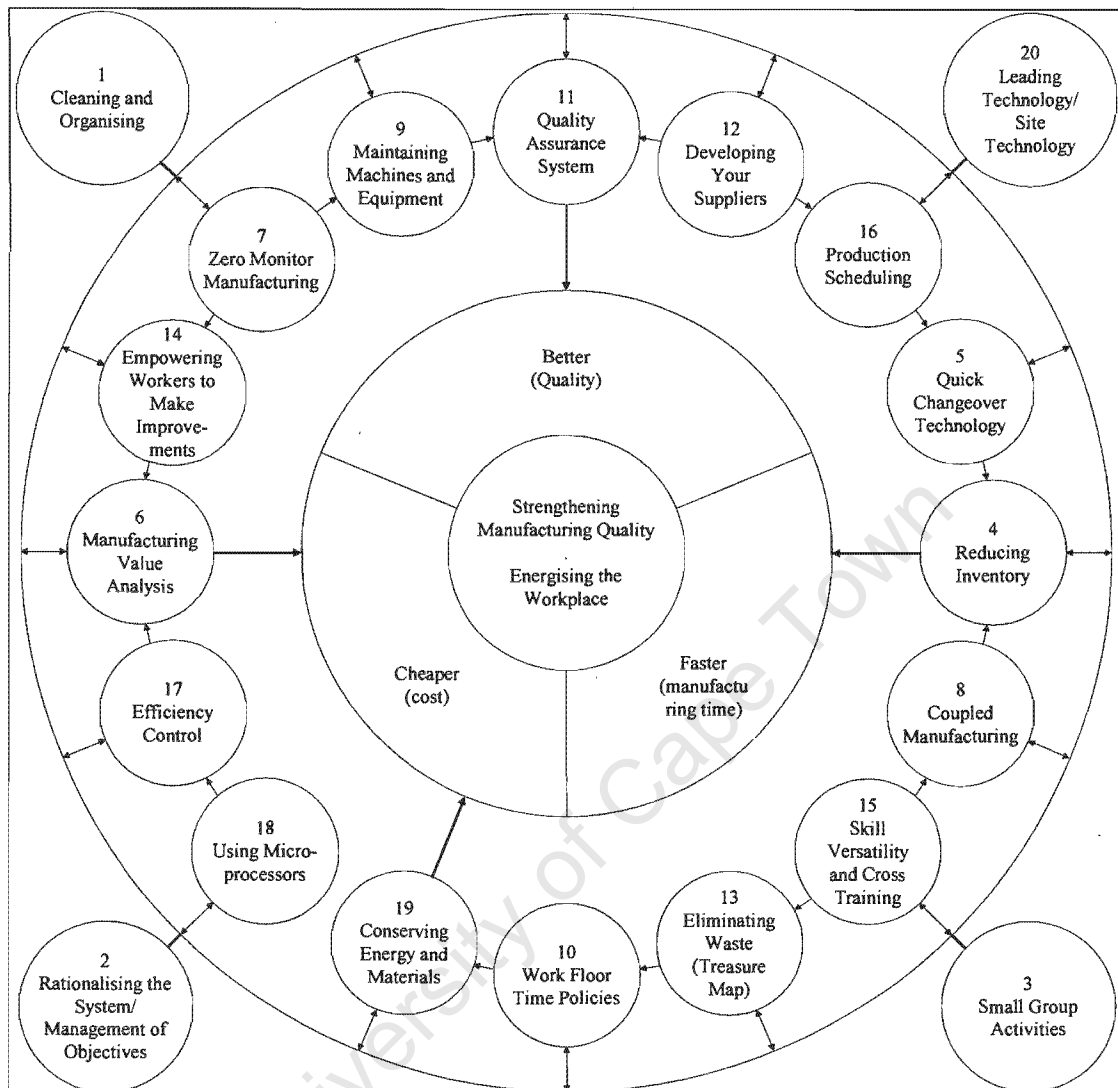


Figure 7: Kobayashi's 20 Key Improvement Areas

Kobayashi believed that *“When these keys are improved simultaneously, they work synergistically to activate the workplace and strengthen the manufacturing quality of the enterprise”*. Where the elements of a stronger manufacturing quality were to make good products, quickly and less expensively. Each key was divided into 5 levels of performance where level 1 represents a low performance level and level 5 the ideal. Kobayashi used “undesirable effects” or “symptoms” as indicators of the various levels. Step by step solutions, or as Goldratt describes them, injections, were suggested to move from an undesirable level to a more desirable level of performance.

5 SYSTEMS THINKING AND THE THEORY OF CONSTRAINTS:

5.1 Systems Thinking:

The following section briefly describes basic systems thinking, its principles, its elements, its purpose and the Theory of Constraints, a systems thinking approach for system improvement.

Webster's new universal unabridged dictionary [26] defines a system as, *"a set of arrangements of things so related or connected as to form unity or an organic whole."*

In practical form a system is an interrelated group of processes that receive inputs from an external environment, process these inputs and produce outputs. For the purpose of this thesis the processes of the system should add value to the inputs thereby producing outputs with a greater value. Figure 8: A Generic System, shows the elements of a system and how it interacts with the environment in which it exists.

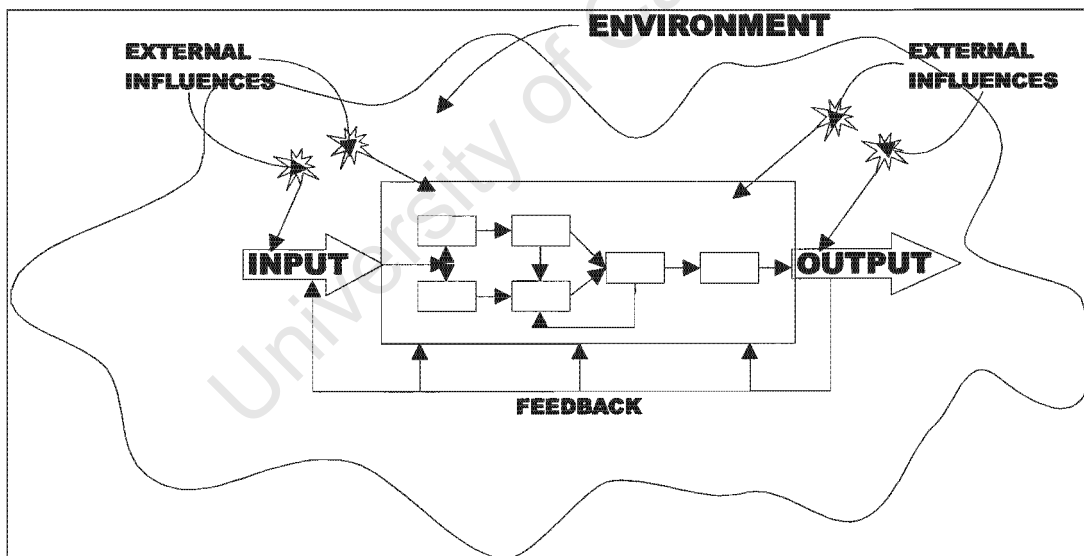


Figure 8: A Generic System

In "Quality and the Theory of Constraints", Dettmer [27] described the three basic systems principals that govern the performance, behaviour and response of the system to external influences, feedback and interventions.

System principle 1. Each and every individual part or element in a system affects the system's overall performance. For example, every operation in a manufacturing system influences the overall performance of that manufacturing system.

System principle 2. Elements within a system are interdependent and how one element within the system affects the overall performance of that system is dependent on at least one other element. For example, consider the simplified manufacturing process represented in Figure 9: A Hypothetical Manufacturing Process. The output of operation 3 is dependent on operation 2, which is dependent on operation 1. If operation 2 receives defective parts processed by operation 1 its output may decrease resulting in a decrease in the overall manufacturing process.

System principle 3. Elements within a system can be grouped together to form subsystems that are subject to the above two principles.

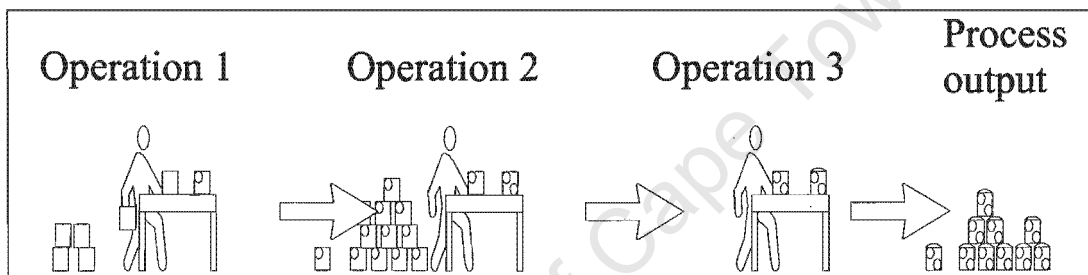


Figure 10: A Hypothetical Manufacturing Process

Effectively improving a system's performance therefore requires an approach that is based upon the three systems principles, commonly referred to as systems thinking. Dettmer [28] points out that in most instances, production managers and problem-solvers use an analytical approach in their attempts at improving their manufacturing systems performance. In using an analytical approach, large systems are broken down and reduced to manageable components or individual system elements. Each component or element is optimised and then reassembled into a "system" solution. Considering each component or individual elements separately results in a loss of system perspective, i.e. seeing the effects of any changes or injections on the system as a whole. Without a perspective of the whole system, effective solutions for improving the system cannot be found.

Both Senge [29] and Flood and Jackson [30] point out that the fundamental problem with the analytical approach to problem solving is that in most cases it treats the symptom that indicates the existence of a problem. The underlying interactions of the system's elements responsible for the symptoms are not addressed and therefore not eliminated. Initially the problem-solver using the analytical approach sees an improvement, but other undesirable effects of the same problem are not eliminated, and after a delay the previously eliminated undesirable effect reappears.

Treating undesirable effects without eliminating the core problem results in the production manager wasting time “fire-fighting”. Short-term improvements can be gained this way but the long-term performance can not be effectively improved. In some cases the manufacturing system performance can deteriorate unnoticed until the core problems lead to business failure. Figure 2: The Effect of Ineffective Management Decision-Making, shows how “fire-fighting” leads to business failure.

The systems thinking approach to problem solving considers the entire structure causing certain behaviour and responses rather than the analytical approach of focusing on events or ‘snap-shots’ of the dynamic system.

Senge [31] discusses the different approaches to problem solving, the reactive approach, the responsive approach and the generative approach. Figure 11: Patterns of Behaviour shows that the system's structure explains why the system behaves as it does and that the behaviour of the system is an accumulation of events occurring over time in the production system. The analytic approach to problem solving is concerned with managing or reacting to events and in some cases responding to patterns of behaviour. The systems thinking approach is concerned with the underlying structure that is responsible for the behaviour of the system or for generating certain behaviour.

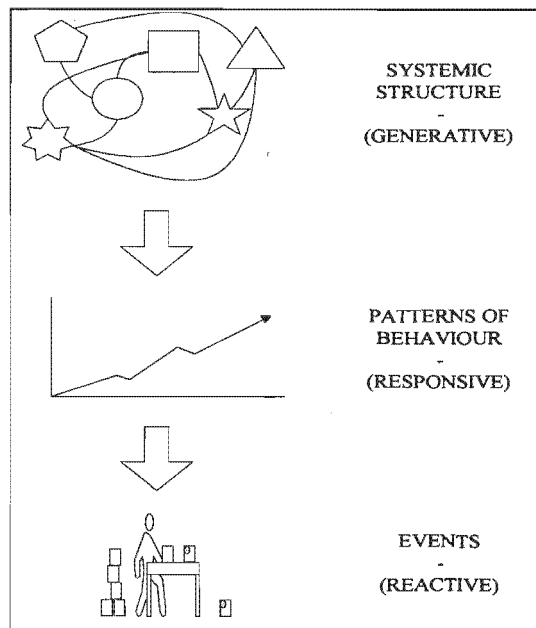


Figure 11: Patterns of Behaviour

5.2 The Theory of Constraints:

The theory of constraints is a management philosophy that takes a systems thinking approach to managing an organisation. It considers the organisation in its entirety and recognises the three basic system principles described earlier. Goldratt [32], in his development of the theory of constraints, defines a fourth system principle.

System principle 4. If the performance of each part of the system is individually maximised, the system as a whole will not behave as well as it could. And conversely, if a system is performing as well as it can, not more than one of its parts will be. This principle is the focus of the theory of constraints.

Dettmer [33] describes how Goldratt illustrates the systems thinking approach by using an analogy of an organisation, a business or part thereof being a chain or network of chains consisting of individual links (system elements or sub-systems). The strength of the chain (performance of the system) is constrained by its weakest link (system constraint).

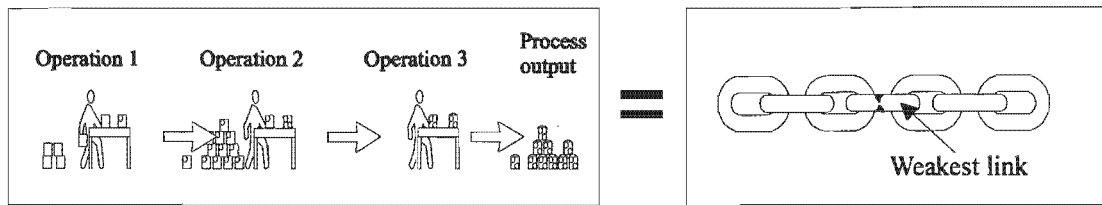


Figure 12: An Analogy of a System

Improving the overall strength of the chain therefore requires strengthening the weakest link. Strengthening any other link will only consume resources without improving the overall strength of the chain. Once the weakest link is strengthened enough to improve the overall strength of the chain another link becomes the weakest link and all efforts must be directed towards it. By constantly focusing on only the weakest link the strength can be continually improved with the least amount of effort.

The theory of constraints therefore attempts to improve the performance of the entire system by focusing on one constraint of the system at a time and not by optimising every element within the system. For example, in a manufacturing business the production department depends on the sales and marketing department selling goods. If the quantity of goods being sold is less than the capacity of the production system, operating the manufacturing system at full capacity by keeping everybody busy all the time, to make sure production efficiencies remain high, will only consume resources increasing operating expenses (all the money the system spends in order to turn inventory into throughput) and inventory (all the money that the system invests in purchasing things that it intends to sell) while throughput (the rate at which an organisation generates money through sales) remains the same.

5.2.1 Constraints to Improved Production Performance:

Goldratt's analogy shows that a constraint in a business operating system is anything that limits it from moving towards or achieving its goal, which Goldratt [34] defines as, "*to make money now and in the future*".

Dettmer [35] states that there are generally two types of constraints, physical constraints and non-physical constraints. A physical constraint is something like the physical capacity of a machine or a workforce with limited skills while a non-physical constraint could be something like an operating procedure or the demand for products.

Physical and non-physical constraints are further categorised into three distinct types of constraints, demand constraints, production constraints and raw-material constraints. The first, demand constraints, concerns marketing of the product and the relationship between the business and its customers, the second, production constraints, concerns the production system and the third, raw material constraints, concerns the relationship between the business and its suppliers.

1) Demand Constraints:

A demand constraint is a non-physical constraint on the output of the business's manufacturing system. Indications that a demand constraint exists include a large inventory of unsold finished goods or a manufacturing system operating at a fraction of full capacity. The existence of demand constraints means that there is excess manufacturing capacity caused by one or a combination of four problems, a poor marketing strategy, unreliable delivery, poor product and service quality, excessively priced goods and product obsolescence.

2) Production Constraints:

Production constraints are made up of three distinct types, policy constraints, machine capacity constraints and labour constraints. Policy constraints are non-physical constraints caused either by company or union policies, rules and procedures. Machine capacity constraints are physical constraints or bottlenecks caused by a single machine or department in a manufacturing system. Labour constraints are a combination of physical and non-physical constraints caused by insufficient workers or inadequate skills of the labour available to operate the manufacturing system at optimal capacity if so required.

3) Raw Material Constraints:

Raw material constraints are physical constraints concerning suppliers, and include short or long-term shortages of particular parts, material, or consumables whose availability is essential to the balanced flow off work through the manufacturing system.

Physical vs. Policy Constraints:

The process of ongoing improvement requires constant change. It also means that previously made decisions or solutions that resulted in improvements to the business's performance in the past lose their effectiveness and become obsolete as time progresses. Policies such as rules, measures and training that were implemented to affect change in the past but are now obsolete gain their own momentum becoming constraints in the present. Dettmer [36] points out that policy constraints not only make up the majority of constraints in most businesses but are less visible than physical constraints and are themselves the cause of most physical constraints.

5.2.2 The Theory of Constraints Thinking Process Tools:

The TOC thinking process provides a structured logical methodology for an ongoing process of improvement. Goldratt's [37] process is based upon continuously determining what to change, determining what to change to and determining how to cause the change.

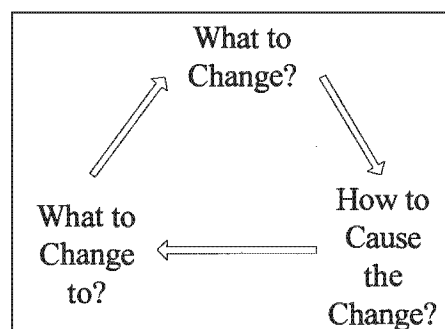


Figure 13: The Change Process.

The tools used to answer these questions are the Current Reality Tree (CRT), the Evaporating Cloud (EC) or Conflict Resolution Diagram (CRD), the Future Reality Tree (FRT), the Prerequisite Tree (PT) and the Transition Tree (TT). These 5 tools are derivatives of the basic effect-cause-effect methodology, presented by Goldratt [38] in “What is This Thing Called Theory of Constraints and How Should it be Implemented?”

Figure 14: TOC Thinking Process Tools, shows the major elements of each of the thinking process tools as well as how they interact and what each of their purposes are in the overall process of implementing change.

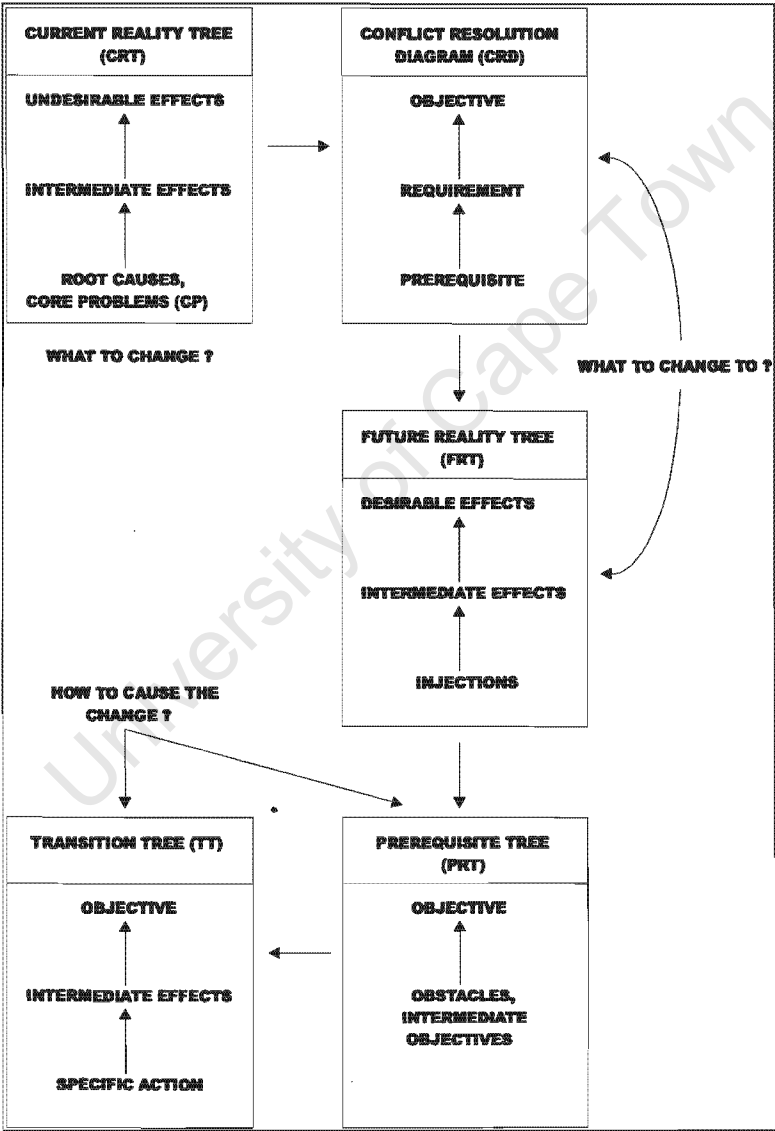


Figure 14: TOC Thinking Process Tools

The Current Reality Tree (CRT):

The Current Reality Tree is a logic diagram that describes the structure of all the major effect-cause-effect relationships in a system. As its name suggests it is a snapshot of the system's current reality. The Current Reality Tree is the tool used to determine "what to change?" in a system by pointing out the few core problems that are responsible for the many undesirable effects present in the system, thereby defining the problem. Senge [39] believes that this is especially important in small manufacturing businesses where resources are limited and finding the area that will give the most leverage with the least amount of effort is essential.

The Evaporating Cloud (EC)/Conflict Resolution Diagram (CRD):

The Evaporating Cloud or Conflict Resolution Diagram helps resolve conflicts in a system. The Conflict Resolution Diagram is structured to show the requirements and the prerequisite to the conflicting elements. The conflict can only be resolved with injections that satisfy all requirements, where an injection is a change of some kind.

The Future Reality Tree (FRT):

The Future Reality Tree is very similar to the Current Reality Tree. The difference is that instead of starting with an undesirable effect and determining the root cause, a solution or injection for eliminating the root cause is proposed and desirable effects caused by the injection are stated. The Future Reality Tree represents the what-if scenarios of a desirable future. Injections can therefore be carefully analysed before they are implemented in a real system. Associated problems or new undesirable effects, referred to as negative branches, can be prevented with either a new injection or with additional planning.

The Prerequisite Tree (PRT):

The Prerequisite Tree is part of the “how to cause the change?” stage of the thinking process. Dettmer [40] states that its purpose is to identify all the obstacles and factors that stand in the way of, or prevents, turning an idea into a solution. The Prerequisite Tree not only shows what obstacles must be overcome but also the sequence in which they must be overcome as well as the conditions that must be in place for the Future Reality Tree to be achievable.

The Transition Tree (TT):

The Transition Tree is the last tool to be used in the thinking process and the second of the “how to cause the change?” stage. The Transition Tree is much like the Future Reality Tree only more detailed. The Transition Tree contains the detailed step-by-step procedures for implementing the necessary injections, which effect the change from the undesirable current reality to the desired future reality.

5.2.3 Causes and Effects, Desirable and Undesirable:

Senge [41] points out that the second system principle, ‘elements within a system are interdependent and how one element within the system affects the overall performance of that system is dependant on at least one other element’, results in two noticeable system behaviour characteristics. The first, for every action there is a reaction, or conversely, for every effect there is a cause. And secondly, there is a time lapse between the cause and its effect.

In the case of manufacturing systems, every action taken or injection made by production managers are causes that have effects that are either desirable or undesirable. Desirable effects are indications that there are improvements being made to the performance of the production system, either by decreasing inventory and or operating expenses while maintaining throughput or by increasing throughput while maintaining or decreasing

inventory and operating expenses relative to the increase in throughput. Undesirable effects, in contrast, are signs that there are constraints limiting the performance of the manufacturing system.

The undesirable effects identified through personal experience, through discussions with other production managers of small manufacturing businesses, through the literature reviewed and through the survey questionnaire are listed in section 9, Small Business Manufacturing System Current Reality Tree.

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6 SURVEY RESEARCH METHODOLOGY:

To ensure that the data gathered, the information generated from the data, the analysis performed on the information and the conclusions drawn from the analysis would be valid and accurate, the method of gathering the data had to be rigorous, effective and focused. The design of the survey followed the structured generic survey structure presented by Jill and Johnson [42], which is diagrammatically shown in Figure 15: Survey Research Design - A Summary.

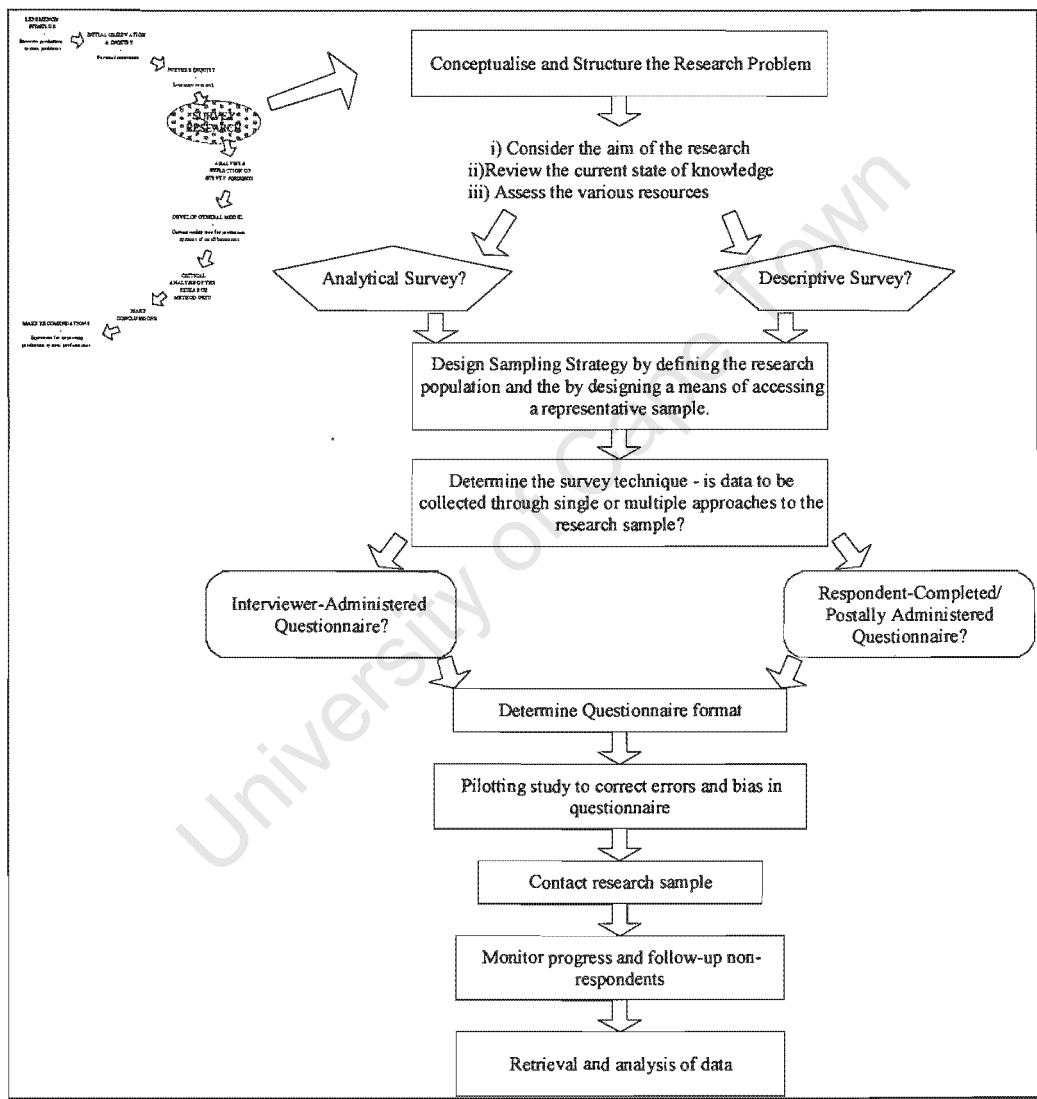


Figure 15: Survey Research Design - A Summary.

6.1 Survey Methodology:

The major tasks shown in Figure 15: Survey Research Design - A Summary, were as follows.

Task no.1: Defining the purpose and objectives of the survey:

The purpose of the survey was:

1. To identify the current reality (the basic characteristics and management) of small business production systems,
2. To determine whether or not the undesirable effects identified through the literature survey, through personal experience and through discussions with other small manufacturing business managers were present in other small manufacturing businesses,
3. To identify undesirable effects that were previously unnoticed, and
4. To identify the underlying root causes of the undesirable effects.

Task no.2: Assessing the limitations placed on the survey research:

The second task of the survey research process was assessing what resources were available for the survey research. Common sense combined with a thorough review of survey research literature suggested that the quantity and quality of the survey results would be directly related to the accessibility and availability of resources.

The greater the resources available, the greater the insight achievable into the research problem, if used effectively.

Task no.3: Designing the sampling strategy:

Before the data was gathered the source of the data had to be determined and considered. Practically, data could not have been gathered from every member of the research

population (all small businesses conforming to the boundary conditions), a representative sample was therefore chosen to survey.

The lack of a comprehensive database of the research population meant that the first task of the survey research process was to construct a sample frame, defined by Fowler [43] as *“a set of people that has a chance to be selected”*.

The sample frame used for this project was constructed from three major sources. The first, from representatives of businesses supplying materials, components, consumables and services to small manufacturing businesses, the second, from the Yellow Pages and Home Improvement supplements of the Argus, and the third, from the list of members of the Tygerberg Chamber of Commerce and Paarden Eiland Metro Association. The key prerequisite of the sample frame was that it had to be representative of the entire research population. This was necessary to ensure that the information generated from it was comprehensive and generaliseable.

The members making up the sample frame are listed in Table No 1 in Appendix 1

Task no.4: Selecting the method of collecting data:

The method chosen for collecting data for this project was a mailed questionnaire form. This method was chosen over other typical survey data collection methods, such as telephonic or personal interviews or the group administration method because the self-administered type questionnaire sent out to the sample members did not require as much personnel, time or money to administer, Fowler [44]. The self-administered questionnaire allowed the respondent to consult with others, to give unhurried and thoughtful answers that did not have to be personally shared with the researcher, and allowed them to answer the questionnaire in their own time. There was one major disadvantage of using the self-administered questionnaire. The lack of personal contact between the respondents and the researcher meant that respondents could not clear any queries associated with the questionnaire. Fowler [45] stated that this could result in

incorrect answers being given or non-response. Furthermore, Fowler [46] stated that “*a letter is not a very effective means of enlisting cooperation*”, resulting in lower response rates compared to survey methods where there is personal contact between the respondents and the researcher.

Task no.5: Questionnaire and question design:

The next major step in the survey design process was designing and compiling a questionnaire to be forwarded to the research sample as an effective means of eliciting information. With the low response rate associated with mail surveys, special attention had to be placed on the questionnaire design to keep non-response to a minimum. The questionnaire was therefore designed to be as clear as possible, as easy to understand and answer as possible, and as precise as possible.

The survey questionnaire form consisted of three major components, the covering letter, the steering instructions and the main body of questions.

The purpose of the covering letter was to encourage the respondents to complete and return the questionnaire form. The covering letter introduced the research to the respondent by providing a brief background to the research, explained the purpose and objectives of the research and explained how the questionnaire fitted in with the research project. The covering letter also provided contact details for respondents to clear any queries and questions about the research and or questionnaire with the researcher.

The purpose of the steering instructions was to explain how the questions contained in the questionnaire form should have been answered. The addition of the thumbnail diagrams made the task of answering the questions easier and clearer resulting in the need for less mental effort. Jankowicz [47] pointed out that respondents who did not fully understand what was required of them would probably not respond.

The third component of the survey questionnaire form, the main body, contained the questions that were intended for validating the respondents and for eliciting data from the sample members that could be later analysed and used for developing and constructing the model.

Task no.6: Piloting the questionnaire:

Five test subjects, four production managers of small manufacturing businesses and one accountant from a wholesale and distribution business, were used to test the questionnaire.

The objectives of the pilot test were:

- 1) to test whether or not the questionnaire would generate sufficient data for the purposes of the research project,
- 2) to test the wording and phraseology of the questions and the instructions, and,
- 3) to investigate the interest generated by the research and by answering the questionnaire.

The pilot group was asked to complete and return the questionnaires and to note any problems in understanding the questions or instructions. Once the pilot results were analysed, the necessary changes were made to the questionnaire, which were again tested until it was ready for use.

Task no.7: Administering the questionnaire and monitoring response:

The self-administered type questionnaire, shown in figure no 63 “Small Manufacturing Business Production Management Survey Questionnaire Form” in Appendix 1, was mailed to each business in the research sample together with the covering letter, and a self-addressed stamped envelope for returning the completed questionnaire. One week after posting the questionnaire a reminder card was sent to the sample members who had not responded. One week later the sample members who had not responded were

contacted telephonically and requested to complete and return the survey questionnaire form.

Task no.8: Retrieval and Analysis of Data:

The data generated by the respondents is laid out in Table 2: Accumulation of the Multi-choice Item Questions of the Survey Questionnaire Form, in Appendix 1, and the major findings are presented and discussed in the next section.

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7 SURVEY FINDINGS – QUESTIONNAIRE RESPONSE:

The following section contains a discussion of the major findings of the survey. These findings consist of current reality and undesirable effects and root causes, the three major components that make up the current reality tree.

The purpose of the first section of the survey questionnaire form, “General Business Details and Operating Background”, was to test whether or not the respondents conformed to the stated boundary conditions. The response revealed that 6 of the 23 respondents fell outside the limits of the boundary conditions leaving only 17 valid respondents from the total of 153 sample frame members contacted, an 11.11% valid response rate.

From question 5: The majority of respondents had less than 5 persons covering management, administration and marketing of their business.

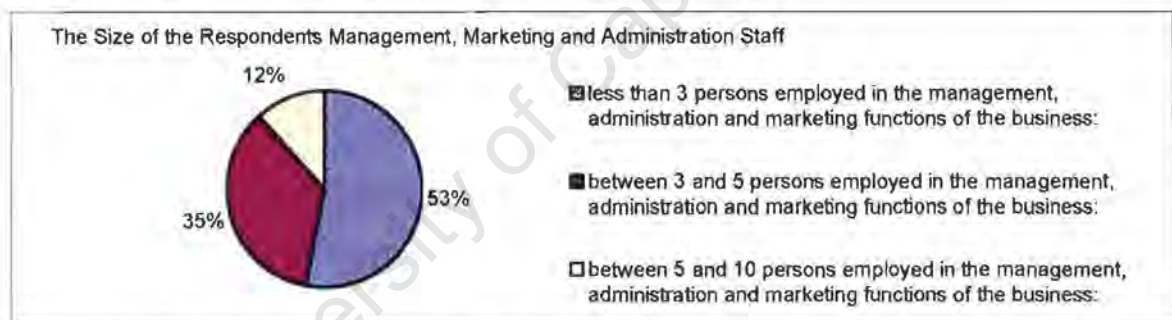


Figure 16: Cumulative Response to Question 5:

From question 7: The majority of respondents had manufacturing systems with mostly labour intensive operations/tasks with some automated operations/tasks. Labour related problems such as, absenteeism, tardiness, work ethic and discipline therefore had a major effect on the performance of the manufacturing system.

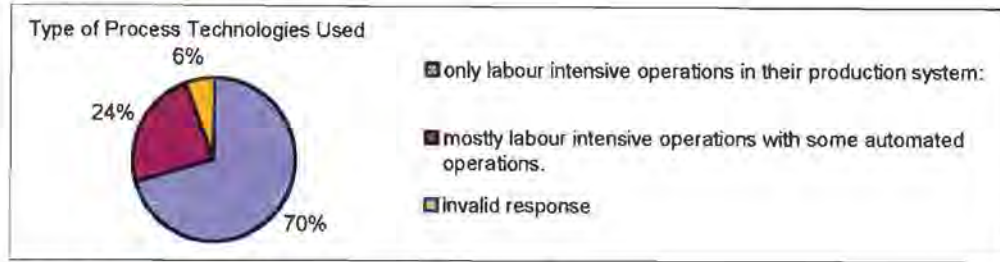


Figure 17: Cumulative Response to Question 7:

From question 8: The workflow through the majority of the respondents' manufacturing systems was mostly a combination of job and batch type flow, described by Chase and Aquilano [48] as disconnected line type flow.

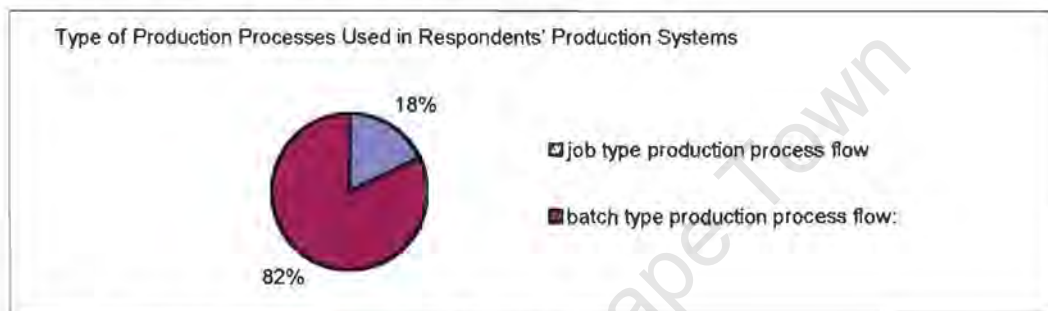


Figure 18: Cumulative Response to Question 8:

The Purpose of the second section of the survey questionnaire form, "Production System & Management Details", was to determine the tasks and functions performed by respondents and to determine the basic characteristics of the respondents' manufacturing systems.

Response to the multi-choice question 10, in which the alternatives were the positions held in the business by the respondent, and in question 11, the tasks performed by the respondent in the daily running of the business, revealed that production managers had to perform a variety of both managerial and non-managerial tasks and functions as well as a number of non-production related tasks and functions. For example, general business management, sales and marketing, debt collection and financial administration.

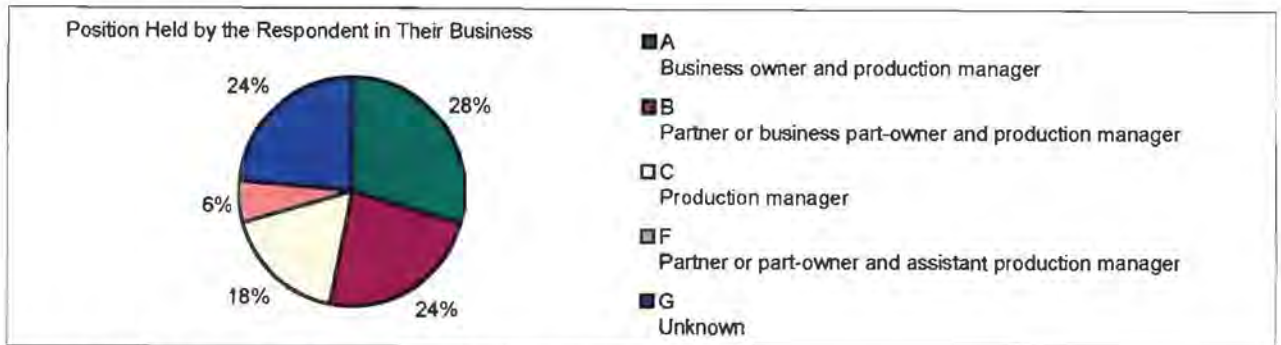


Figure 19: Cumulative response to Question 10.

With such a variety of tasks and functions to cover, not everything could be done effectively. The easy and familiar tasks or functions were probably performed thoroughly with the difficult and unfamiliar tasks and functions rushed and incompletely performed.

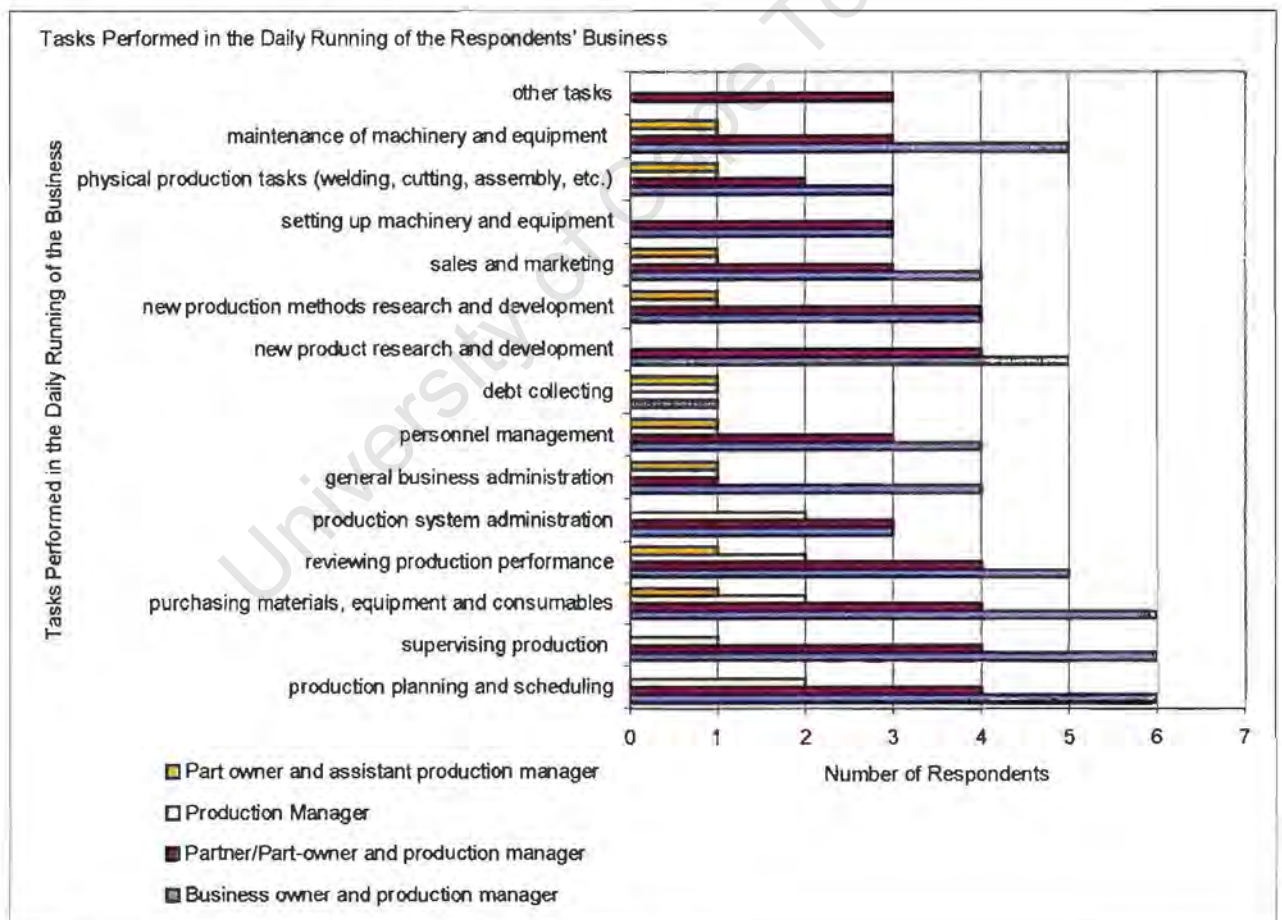


Figure 20: Cumulative Response to Question 11.

Response to the multi-choice questions 12 through 18 revealed the following information on how the respondents manage their manufacturing systems with the focus on workflow through their systems.

From question 12: The majority of respondents had manufacturing systems laid out with either similar machinery/equipment or operations grouped together, typical of a process layout (job-shop) or with workcenters arranged according to the progressive processing steps with backtracking of work through the process, typical of product layout (flow-shop). Both of these process layouts however, create problems and or extra unnecessary work. In the case of the job-shop type layout there is usually excessive movement of work through the process while in the flow-type layout with backtracking scheduling the workflow becomes extremely complex and there is an excessive amount of movement of work through and around the manufacturing process. One respondent had a manufacturing process that was laid out according to the limited space available, an indication of the limited resources available to some small businesses.

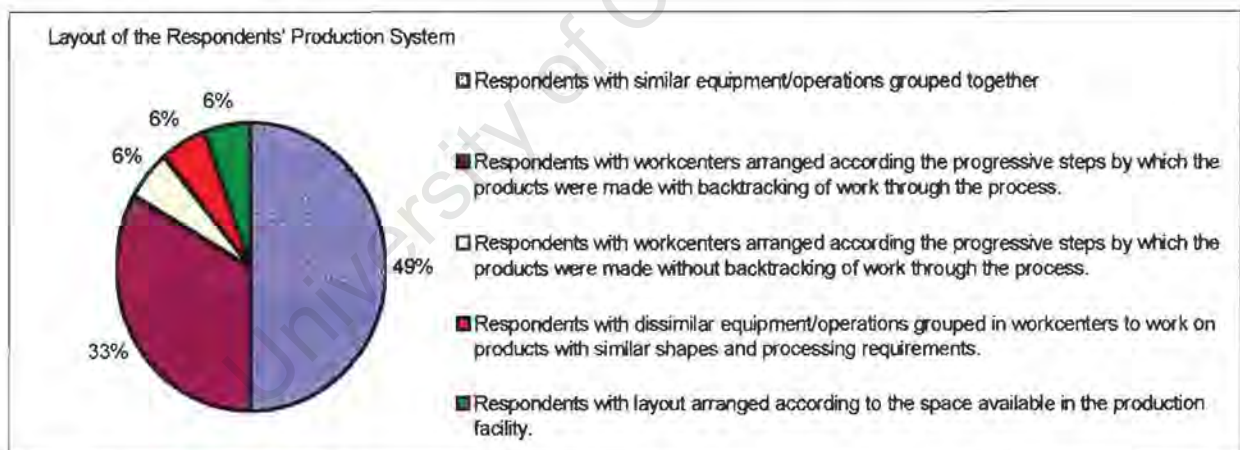


Figure 21: Cumulative Response to Question 12.

From question 13: The majority of respondents had mostly general-type machinery and equipment in their manufacturing systems. The use of mainly general-type machinery and equipment is necessary for a low volume, multiple item product mix produced in a disconnected line type flow manufacturing environment where the availability of capital is severely limited. Chase and Aquilano [49] states that the use

of general-type machinery and equipment allows the manufacturing system to be more flexible than one with highly specialised machinery and equipment. General-type machinery and equipment does however, require multiple and lengthy changeovers as well as skilled staff to perform the changeovers and to operate the machinery and equipment.

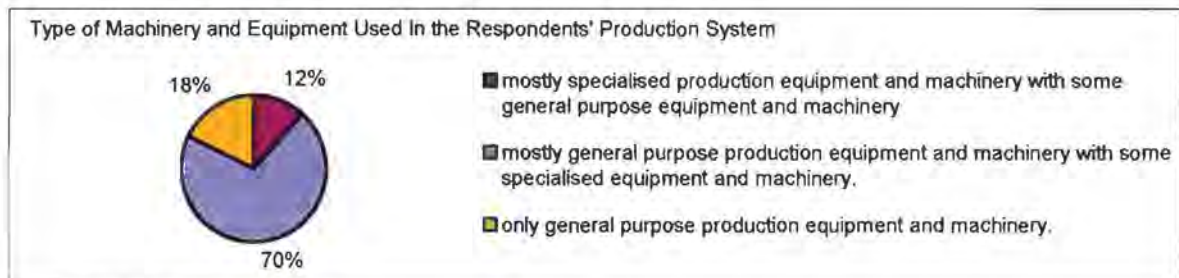


Figure 22: Cumulative Response to Question 13.

From question 14: Approximately half the respondents determined the batch sizes of parts and products by either adding some stock items to order quantities in order to improve workcenter efficiencies and to take advantage of larger economic order quantities, or by scheduling all operations for maximum capacity. Only one of the respondents determined the batch size by scheduling all operations in order to balance the flow of work through their manufacturing process.

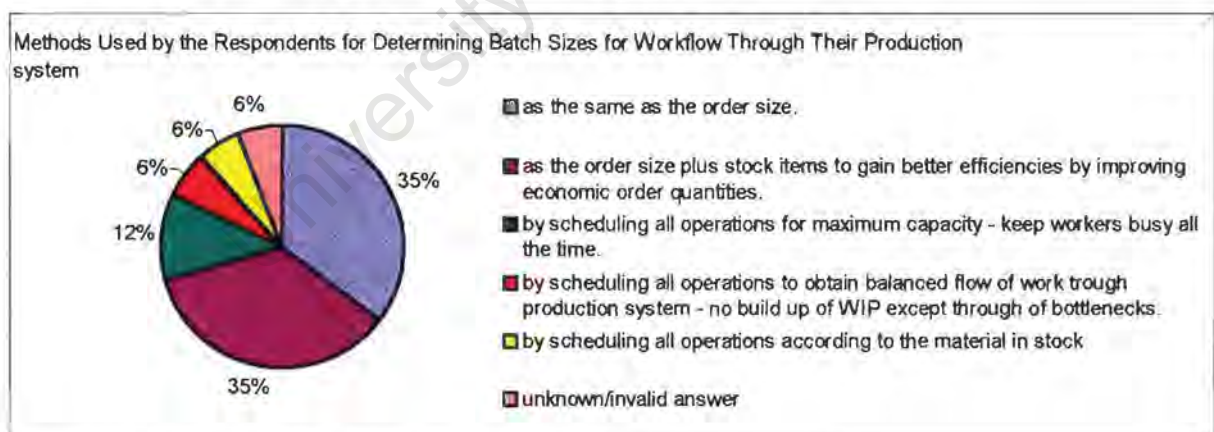


Figure 23: Cumulative Response to Question 14.

From question 15: There were slightly more respondents who differentiated between process and transfer batches than those who did not. In cases where the transfer batches were smaller than process batches, material that had been processed by one

operation moved to the next workstation, regardless of the progress of processing on other material in its batch. In cases where the transfer batch was equal to the process batch, material and parts from each batch were kept together and only proceeded from one workstation to the next when all processing was complete on that entire batch. In manufacturing systems where the transfer batch is equal to the process batch the flow of work is unbalanced as work moves through the process in waves. Unbalanced workflow caused buildups of work-in-process, late deliveries, late notification of quality problems and overloading of workcenters.

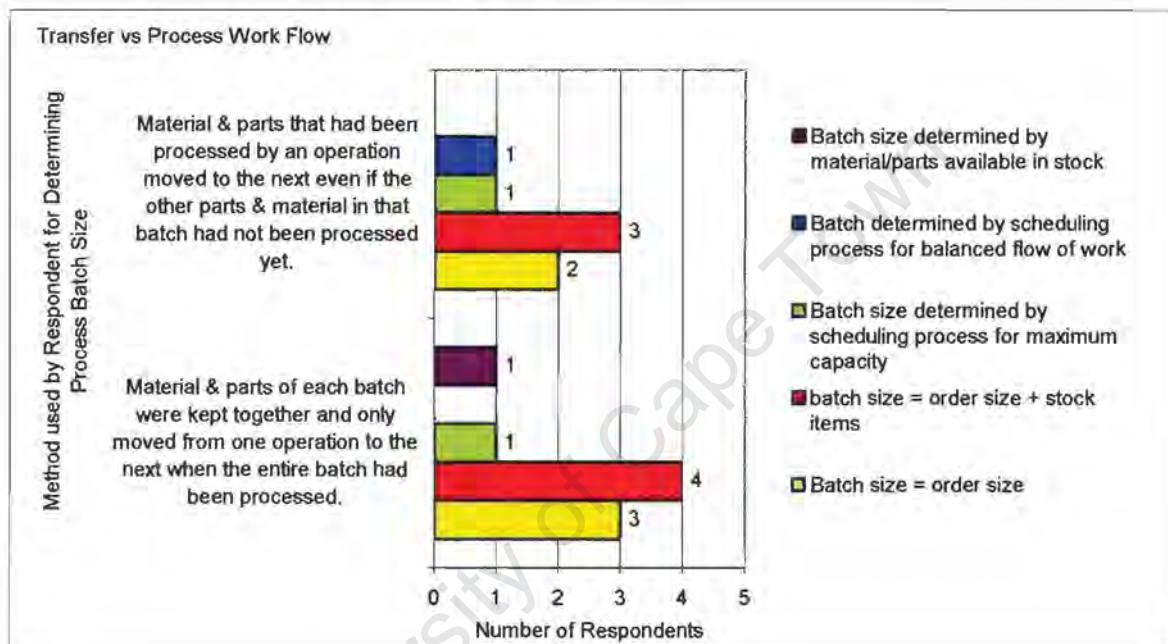


Figure 24: Combined Cumulative Response to Questions 14 and 15.

From question 16: Respondents' production workforces were comprised of mostly unskilled (labourers) or semi-skilled (operators) workers. The lack of skill content meant that only simple operations and tasks could be performed. The general-type equipment used in the majority of the respondents' manufacturing systems required skilled workers to set-up and operate. The lack of skilled labour often resulted in machine and equipment breakdowns, inconsistent quality and the need for constant supervision of the workers by management. Extensive and ongoing training was therefore required in order for the workers to perform more complex operations or tasks.

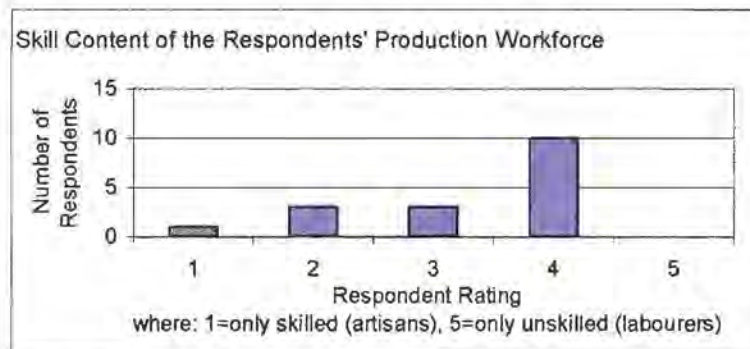


Figure 25: Cumulative Response to Question 16.

From question 17: The respondents' production workers had mostly minor to medium influence over their own working environment.

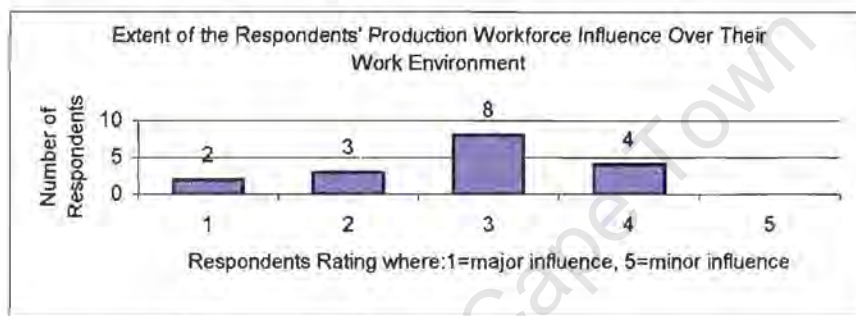


Figure 26: Cumulative Response to Question 17.

From question 18: The majority of respondents remunerated their workers with wages and salaries only with one respondent offering some type of financial incentive with paid wages or salaries and one offering some type of non-financial incentive.

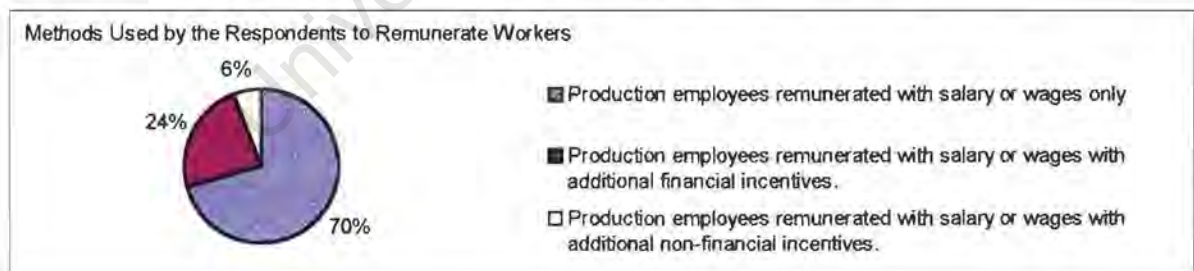


Figure 27: Cumulative Response to Question 18:

The purpose of the third section of the survey questionnaire form, “Production System Problems and Their Causes”, was to identify the undesirable effects that respondents encountered in managing their manufacturing systems and to determine possible underlying root causes of the undesirable effects.

Responses to the multi-choice questions 19 through 24 revealed the following information regarding the quality of goods produced in the respondents' manufacturing systems.

From question 19: The majority of respondents had clearly stated and set quality standards for goods that they produced with the most common method of ensuring that the standards were adhered to was by constant visual checking by the production manager. In the instances where respondents did not have clearly stated and set quality standards, the production manager checked goods, if they conformed to customer specifications or requirements they were shipped, if not, they were either scrapped and replaced or reworked.

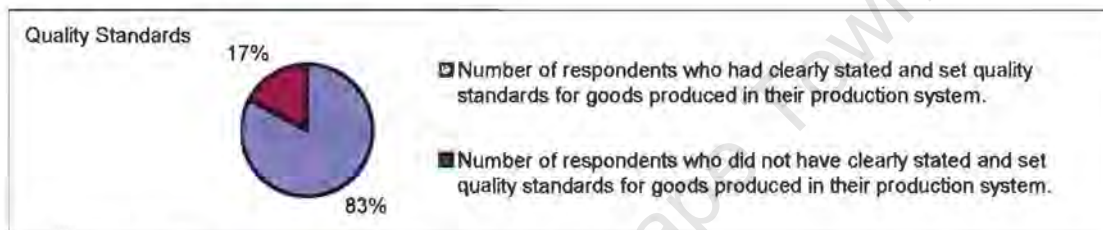


Figure 28: Cumulative Response to Question 19.

From question 20: The majority of respondents had defective or substandard product return rates of less than 1% of all goods shipped with the balance having defective or substandard product return rate of between 1% and 5% of all goods shipped.

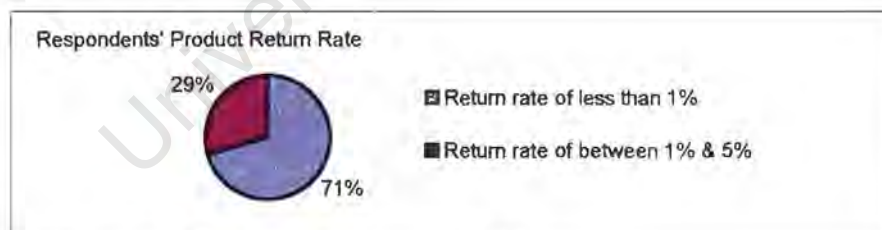


Figure 29: Cumulative Response to Question 20.

From question 21: The majority of respondents rated the quality of goods leaving their manufacturing systems as consistently to the required standard or consistently above required standard.

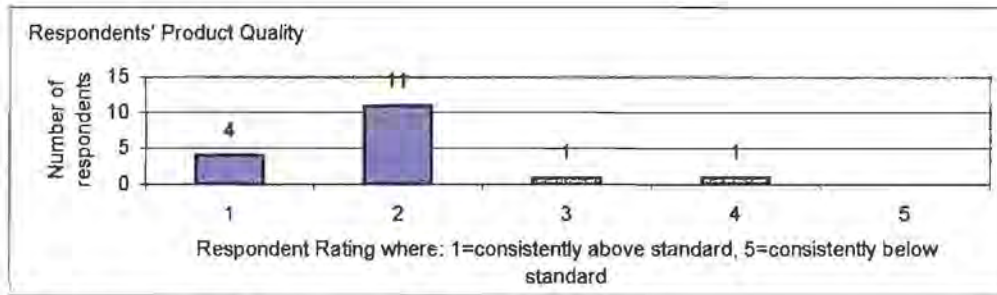


Figure 30: Cumulative Response to Question 21.

As there were numerous causes of uncontrolled quality problems in the majority of the respondents' manufacturing systems a large amount of rework was possibly required to achieve the high standard of quality and the low return rate. Respondents believed the main causes of substandard quality of goods produced in their manufacturing systems to be:

- A. Unmotivated employees that had no interest in their work.
- B. Substandard or defective raw materials, parts and or consumables supplied by vendors.
- C. Highly repetitive and monotonous work that lead to a loss of concentration and subsequent mistakes that went unnoticed.
- D. The loss of production time through production employee absenteeism and tardiness created pressure on other workers to rush their work causing mistakes.
- E. Product specifications and desired quality standards were not effectively communicated to workers.
- F. Insufficient supervision of the workers.
- G. A lack of general quality awareness.
- H. A lack of built in quality controls throughout production.
- I. Worker negligence.

Figure 31: Severity of Causes of Substandard Quality shows the percentage of respondents who believed that these causes were responsible for substandard quality of goods produced in their manufacturing systems.

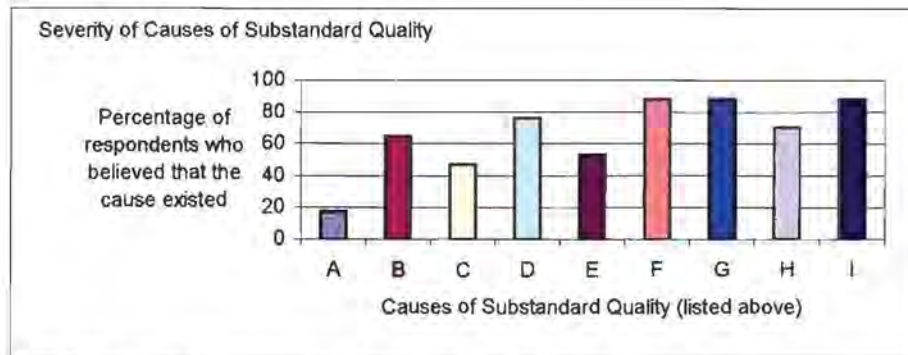


Figure 31: Severity of Causes of Substandard Quality

From question 22: The production manager was responsible for checking the quality of parts and products produced in the majority of the respondent's manufacturing systems. To have the low defective or substandard return rates identified through question 20 the production managers possibly had to spend a large amount of time checking the quality of work produced, time that should have been used more productively.

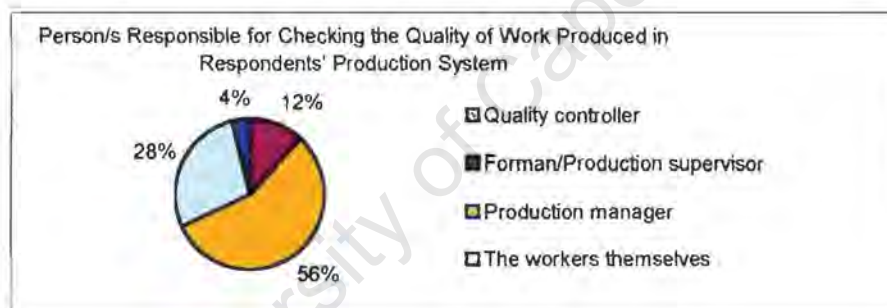


Figure 32: Cumulative Response to Question 22.

From question 23: The majority of the respondents noticed defects or quality problems either very early or very late in their manufacturing systems. Noticing defects or substandard quality before processing began or in the early stages of processing indicated that there the materials, parts and consumables being used in the system were not to standard and that there was no quality inspection of these parts entering the system. Noticing defects or substandard work late in the manufacturing system or as goods are to be despatched indicates a lack of quality control in the manufacturing system. The last minute rework or replacement probably disrupted the workflow through the manufacturing process causing delays, and added pressure on

the workers to complete the affected orders on time. Noticing defects or substandard work at varying stages through processing indicated that although there were constant quality checks by the workers or by the production manager, quality was not designed into the process or standard methods were not adhered to resulting in a number of possible substandard work sources.

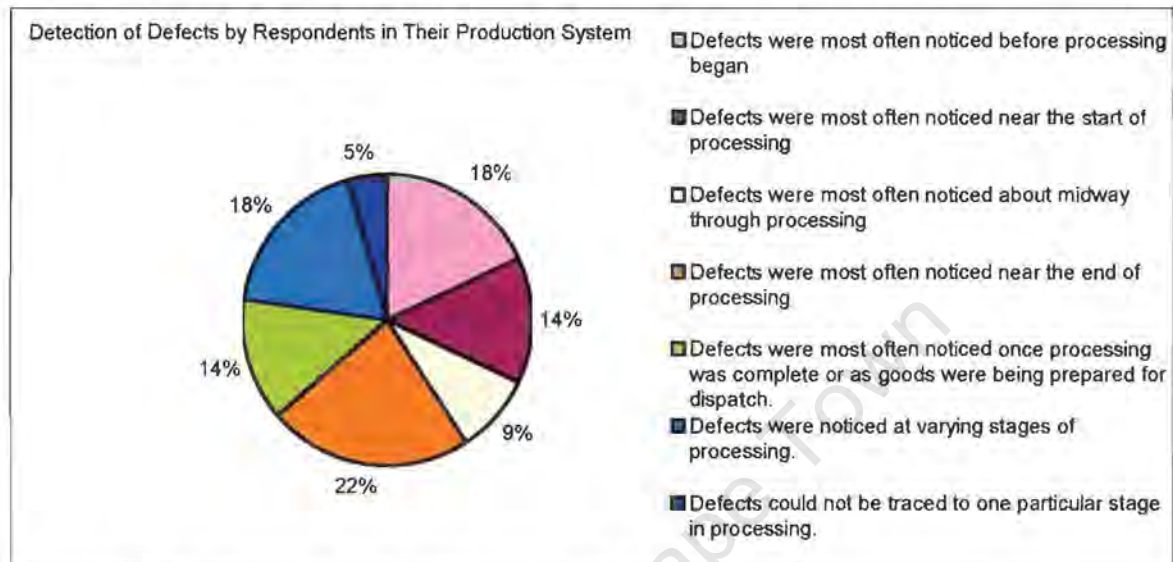


Figure 33: Cumulative Response to Question 23.

From question 24: The majority of the respondents had clearly defined standard work methods and procedures for the operations in their manufacturing systems. The workers however, only adhered to these standard work methods and procedures when under supervision by management.

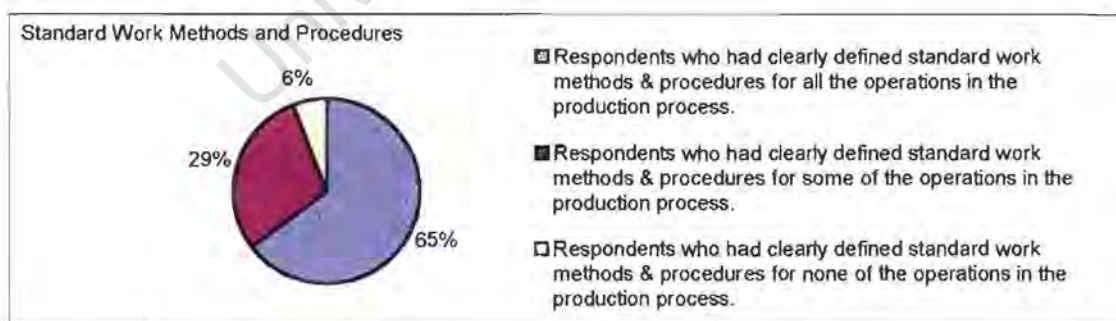


Figure 34: Cumulative Response to Question 24.

From question 25: Only two of the respondents rated the due-date delivery performance of their manufacturing systems as always on time. Although the

majority of the balance of respondents rated the due-date performance as almost always on time it could be seen as an undesirable effect as late deliveries can lead directly to loss of sales.

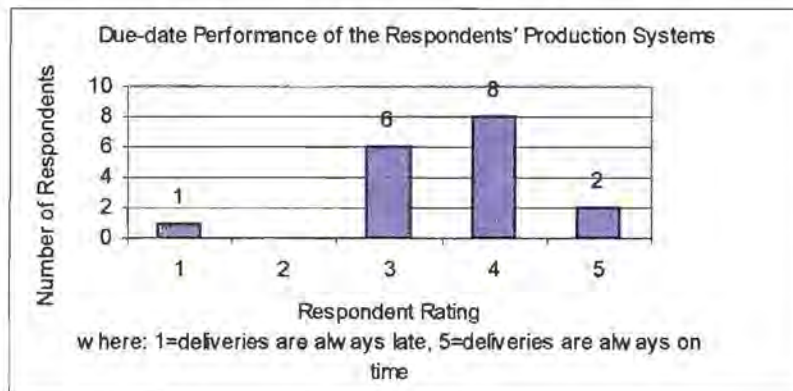


Figure 35: Cumulative Response to Question 25.

The respondents believed the following to be the causes of production lead-times exceeding the promised delivery lead-times.

- A. An excessive amount of production time was lost due to worker absenteeism and tardiness.
- B. Substandard or defective raw materials and or parts required additional unplanned work.
- C. Deliveries by suppliers were constantly late.
- D. Necessary raw materials, parts and or consumables were constantly unavailable.
- E. An excessive amount of production time was lost due to machine or equipment breakdowns.
- F. The quantity of goods on order exceeded the actuality (the current achievement with existing resources and constraints) of the manufacturing system.
- G. Extreme competition lead to promised lead times being unrealistically short.
- H. Inconsistent worker productivity resulted in some tasks/operations taking longer than usual.
- I. Production planning was ineffectively performed.
- J. Poor cash flow into the business resulted in the inability to purchase raw materials necessary for production.

K. Workers not working when they should have been, i.e. milling around talking to one another, looking for tools, looking for parts, etc.

Figure 36: Severity of Causes of Poor Due Date Performance shows the percentage of respondents who believed that these causes were responsible for production lead times exceeding promised delivery lead times.

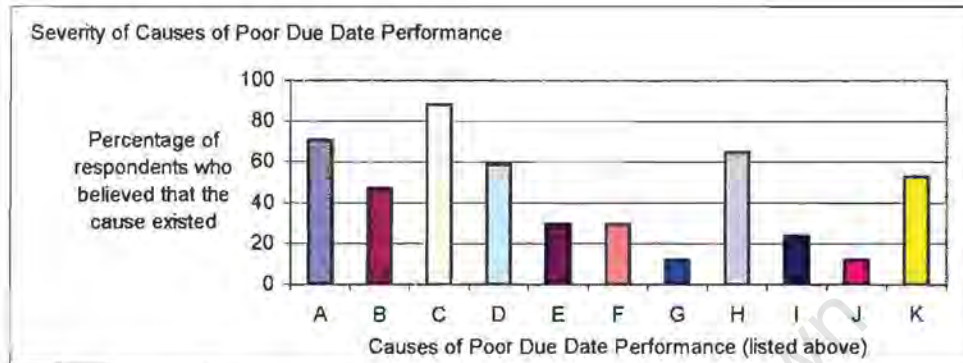


Figure 36: Severity of Causes of Poor Due Date Performance

Response to the multi-choice item questions 26 through 31 revealed the following undesirable effects concerning the respondents' production workforces.

From question 26: A major portion of the respondents lost between 5% and 10% of their average production time to absent workers.

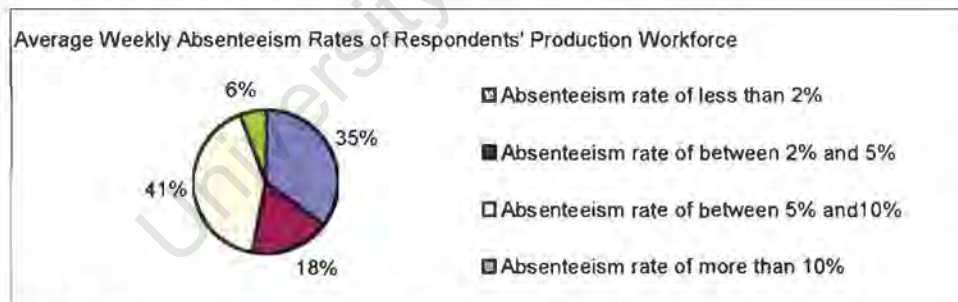


Figure 37: Cumulative Response to Question 26.

Respondents believed the following to be undesirable effects caused by worker absenteeism.

A. Carrying costs increased due to excessive quantities of stock having to be carried to avoid delays caused by absent workers.

- B. The quality of goods decreased and or scrapped work increased due to workers having to perform unfamiliar tasks/operations that would usually have been performed by the absent workers.
- C. The loss of production time resulted in delays in production and late deliveries.
- D. The loss of production time meant that overtime was necessary to complete orders on time, thereby increasing operating expenses.
- E. The relationship between management and the constantly absent workers was strained.
- F. Flow of work through the manufacturing system was disrupted with work-in-process building up at the absent workers' workstations.
- G. The production manager had to constantly re-plan production.
- H. Management had to perform physical tasks in the manufacturing system in order to ensure orders were completed and delivered on time.

Figure 38: Severity of Undesirable Effects Caused by Absent Workers shows the percentage of respondents who had to deal with these undesirable effects in managing their manufacturing systems.

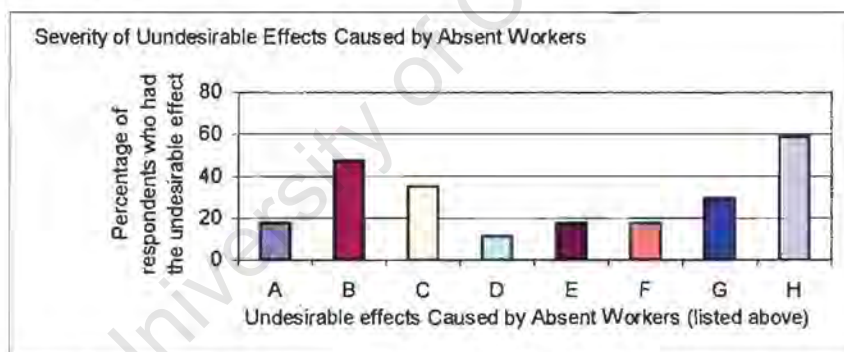


Figure 38: Severity of Undesirable Effects Caused by Absent Workers

From question 27: Although the majority of respondents rated the morale of their production workforce to be fairly high there were indications that low morale could possibly be the cause of the following undesirable effects.

- Workers did not take interest in their work.
- The productivity of the workers was inconsistent.
- Workers were not willing to help one another.

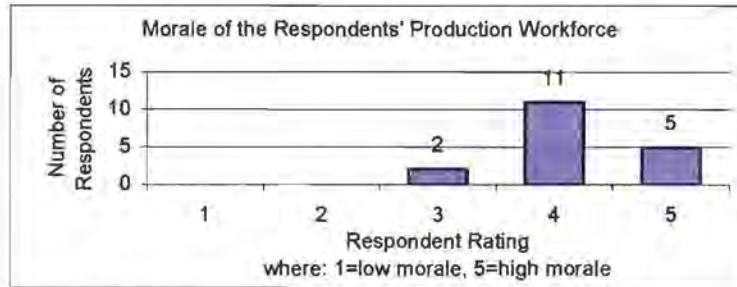


Figure 39: Cumulative Response to Question 27.

From question 28: Although the majority of respondents rated the discipline (attitude towards work and management, punctuality for work and adherence to instructions and company rules) of their workers to be fairly good there were some indications from elsewhere in the questionnaire that there were problems associated with poor discipline, namely;

- workers not working when unsupervised,
- worker tardiness,
- theft of raw materials, goods and tools from the manufacturing system,
- workers ignoring instructions,
- the dismissal of production employees, and
- workers not adhering to standard work methods or procedures.

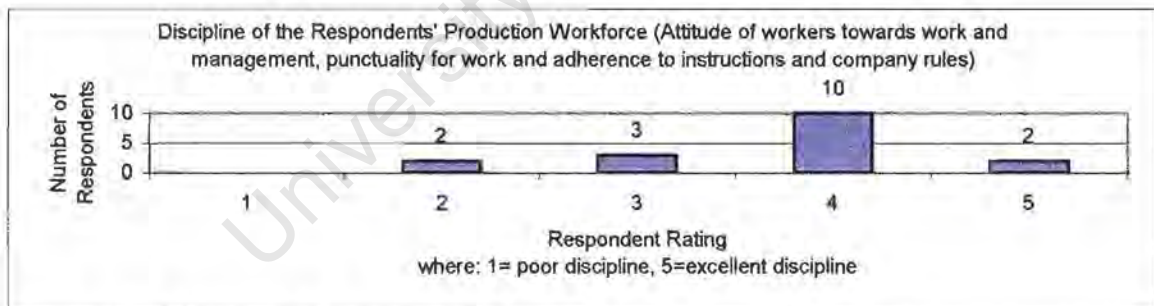


Figure 40: Cumulative Response to Question 28.

From question 29: The production worker turnover rate (worker turnover rate = no of workers that left business in 1997/ average no of workers in the business in 1997) of just over half the respondents was undesirably high. Having to constantly replace production workers resulted in a large amount of time being spent by management

and experienced workers training and supervising the new workers, substandard quality and a production rate that never reached its full potential.

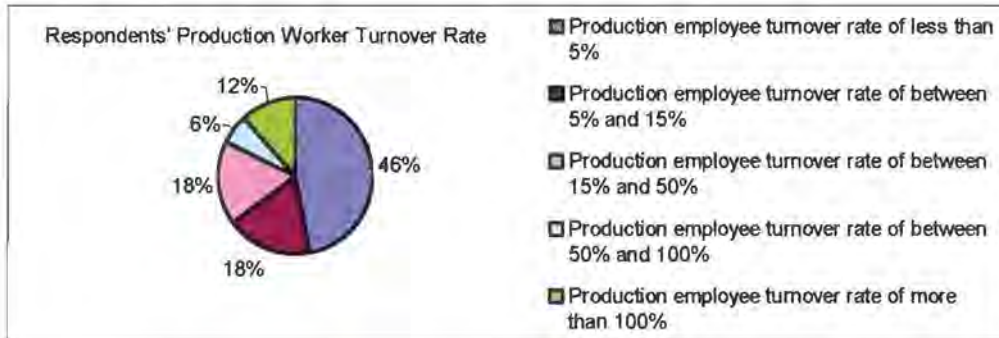


Figure 41: Cumulative Response to Question 29.

From question 30: Workers that resigned or absconded accounted for approximately half the respondents' production worker turnover. This indicated that either the workers did not like the environment in which they worked or the work that they performed or that they received better job offers elsewhere.

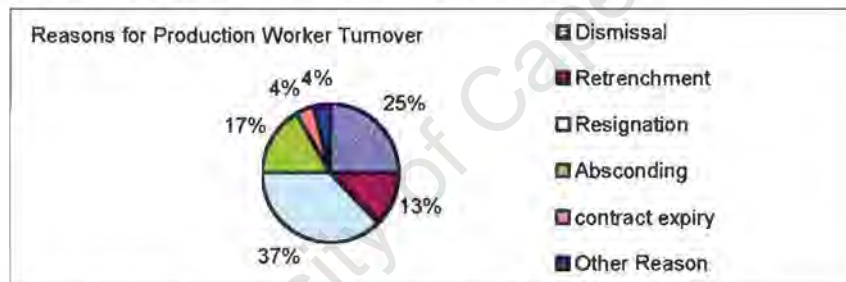


Figure 42: Cumulative Response to Question 30.

From question 31: The productivity level of the respondents' production workforces was in most instances well below the expected productivity levels.

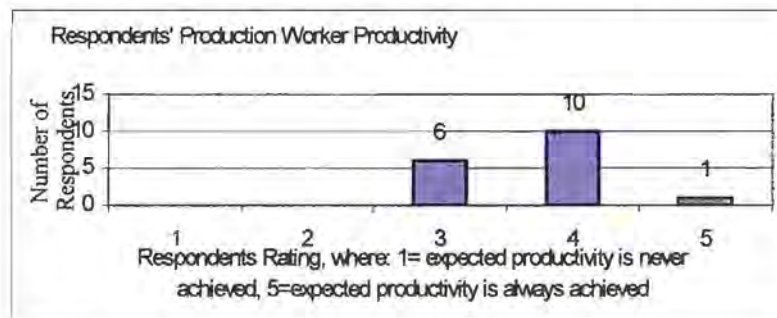


Figure 43: Cumulative Response to Question 31.

Respondents believed the following to be the causes of lower than expected production worker productivity.

- A. Insufficient supervision of the production workers by management,
- B. a lack of effective communication between management and workers,
- C. the late arrival of supplies that resulted in idle workers,
- D. a lack of understanding of the work that the workers performed,
- E. worker laziness,
- F. a lack of the necessary skills or insufficient training of the workers, and
- G. unmotivated workers.

Figure 44: Severity of Causes of Poor Worker Productivity shows the percentage of respondents who believed that these causes were responsible for lower than expected worker productivity.

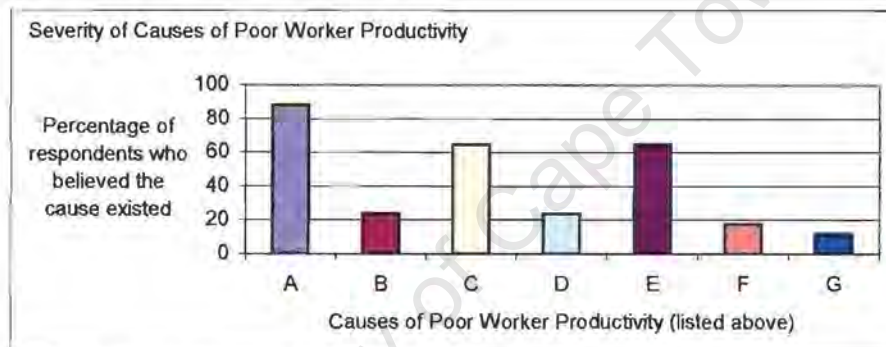


Figure 44: Severity of Causes of Poor Worker Productivity

From question 32: The majority of the respondents rated the cleanliness of their manufacturing facilities to be around average. This indicated that the planning and organising of the manufacturing facility was not as effective as it should have been and that cleanliness was not an important management issue.

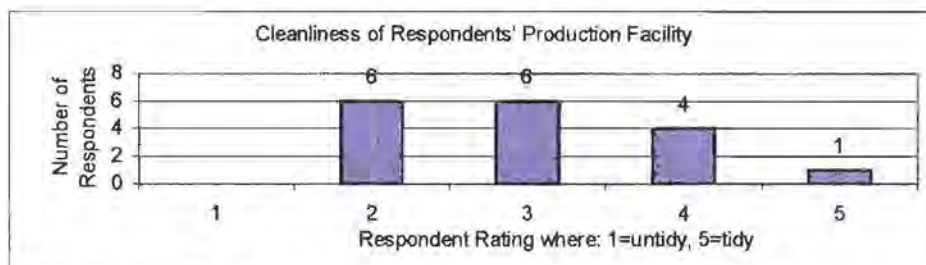


Figure 45: Cumulative Response to Question 32.

Response to the multi-choice item questions 33 through 37 revealed the following undesirable effects concerning material handling in and workflow through the respondents' manufacturing systems.

From question 33: Approximately a quarter of respondents had a problem with raw materials, parts, work-in-process waiting between workcenters, partially finished and finished goods disrupting the workflow through their manufacturing process. This resulted in things having to be moved around continuously, damage being done to the raw materials, parts, work-in-process and finished goods and injuries to the workers. This undesirable effect indicated that the quality of manufacturing planning and organising was poor.

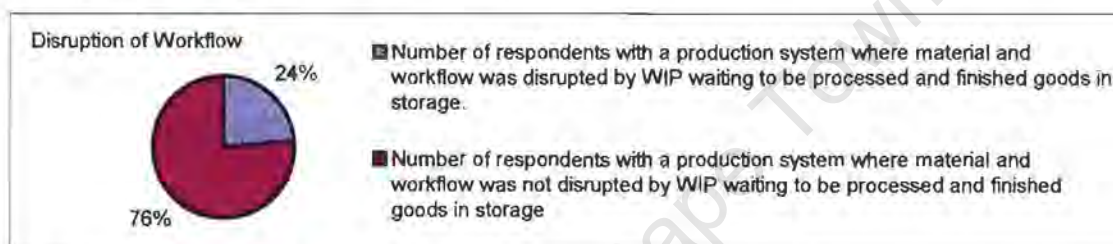


Figure 46: Cumulative Response to Question 33.

From question 34: Just under a third of the respondents had a problem with raw materials, parts, work-in-process, partially finished and or finished goods being misplaced, stolen or damaged during its wait between operations or in storage. This lead to delays in production, the constant expediting of work to replace the missing goods and to repair the damaged goods and a strained relationship between management and workers. Once again this problem indicated that the quality of manufacturing planning and organising was poor.

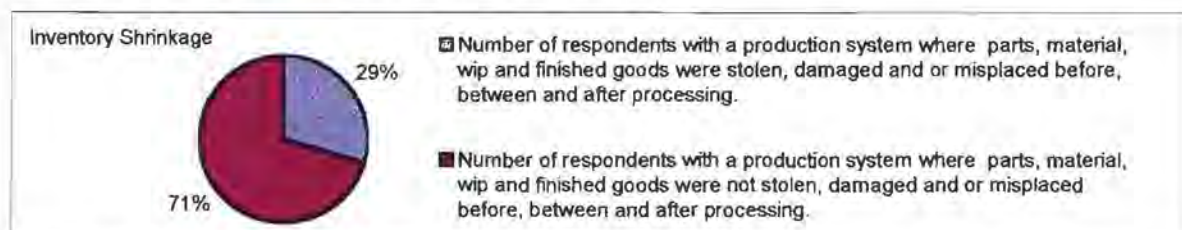


Figure 47: Cumulative Response to Question 34.

From question 35: Just over half the respondents had a problem of parts and materials not always being ready when required for processing.

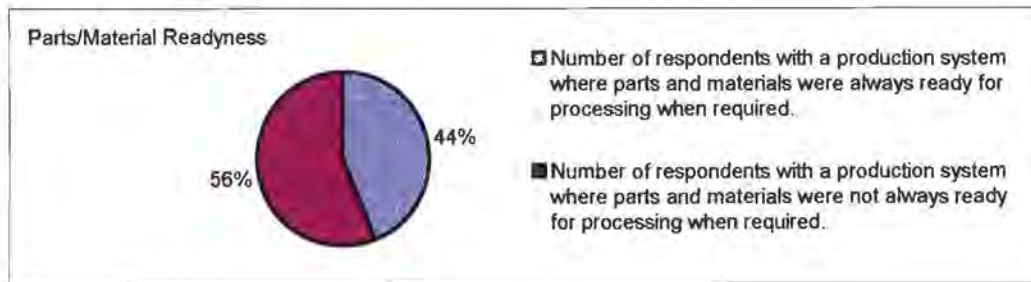


Figure 48: Cumulative Response to Question 35.

From question 36: The response to the multi-choice item question concerning the reasons for respondents having to expedite work revealed that a third of the respondents were more concerned with worker/equipment efficiencies than with the overall performance of the system. The fact that the majority of respondents had to expedite work for late or urgent orders indicated a lack of effective production planning and control. Although the characteristics of the disconnected line-type flow manufacturing process required expediting, management could possibly have reduced the amount of unnecessary expediting and used the time in more productive ways.

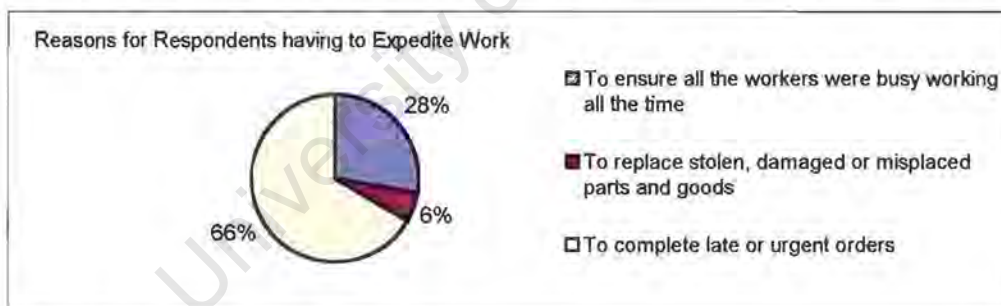


Figure 49: Cumulative Response to Question 36.

From question 37: The bottleneck operation in the majority of the respondents' manufacturing processes changed from one operation to another (wondering bottleneck), a characteristic of disconnected line-type workflow. The balance of respondents had either bottleneck operations that remained unchanged or claimed to have no bottleneck operation. There was a possibility that the respondents who

claimed not to have any bottlenecks did not understand what a bottleneck was or had excess capacity making the market the bottleneck to increased throughput.

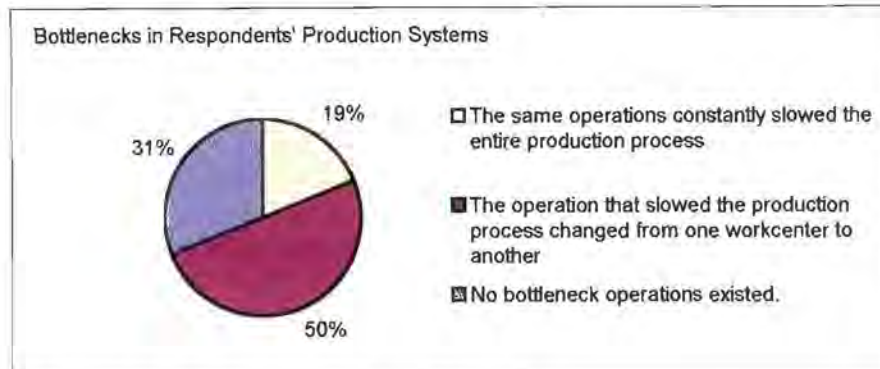


Figure 50: Cumulative Response to Question 37.

Response to the multi-choice item question 38 revealed the following to be the causes of machine and equipment breakdowns.

From question 38:

- A. There was a lack of routine maintenance on machinery and equipment.
- B. Workers disregarded the correct operating instructions and procedures.
- C. The machinery was old and in poor condition.
- D. Machinery and equipment used in the manufacturing system was incapable of handling the work it was used for.

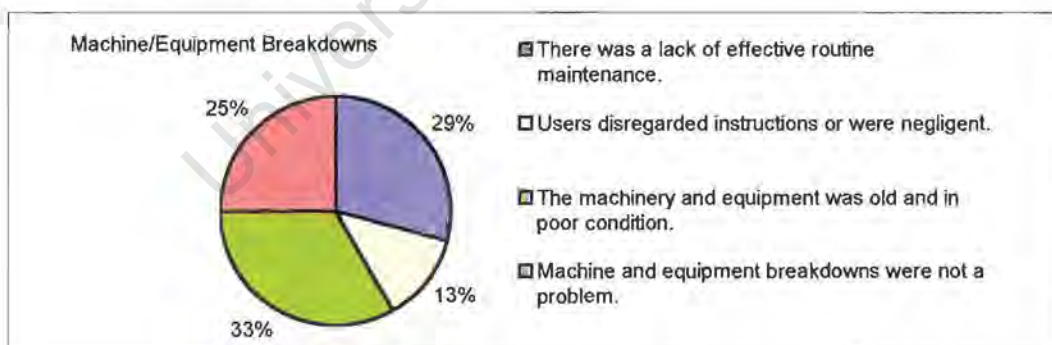


Figure 51: Cumulative Response to Question 38.

Response to the multi-choice item question 39 and open-ended question 40, where the respondents were asked to rate the service received from suppliers and describe any problems regarding 1) the delivery performance of suppliers, 2) the quality of goods

received from suppliers, and 3) the general attitude of suppliers to their businesses, revealed the following undesirable effects.

- Deliveries were often late causing delays in the manufacturing system that lead promised lead-times being exceeded.
- Goods received were often substandard resulting in unplanned additional work having to be performed to correct the goods.
- Goods received were often substandard resulting in substandard products being produced.
- The poor service by suppliers led to management stress.
- Excessive amounts of raw materials and parts had to be kept in stock to counter supplier stockouts or unreliable deliveries.
- Production planning had to constantly be re-planned to deal with late deliveries.
- Excessive amount of time was spent by management chasing suppliers.
- Overtime was often required to make up for the delays caused by late or short deliveries.

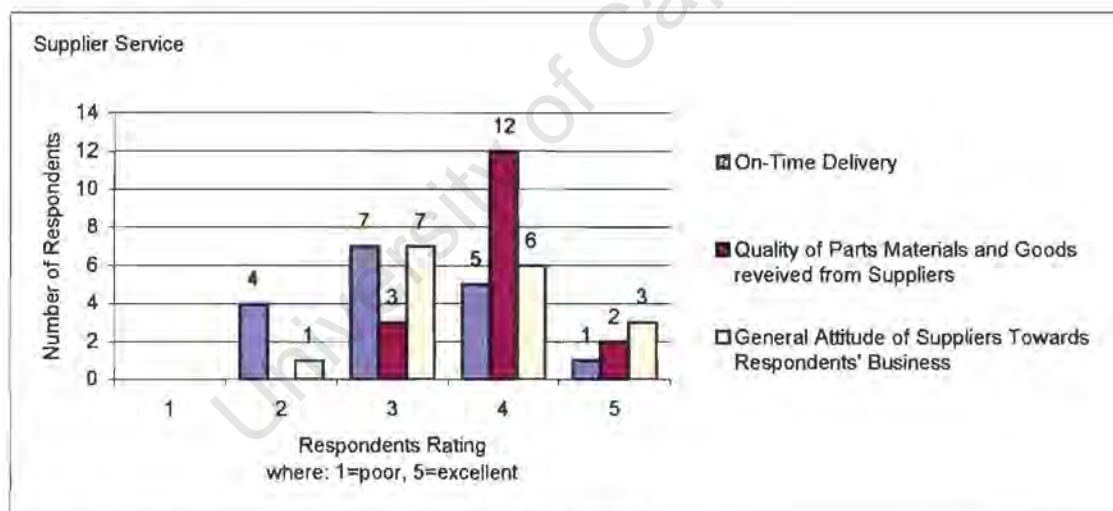


Figure 52: Cumulative Response to Question 39.

From question 41: Response to the open-ended question 41, where the respondents were asked to describe how the lack of capital, management expertise, management time, educated and skilled workforce, effective communication between management and production workers or any other resources or skills affect the management of their manufacturing system, revealed the following.

- A. The lack of managerial expertise resulted in poor budgeting and cash flow problems.
- B. There was not enough time to perform all the necessary managerial functions.
- C. There was a lack of effective planning and organising.
- D. The lack of effective communication between management and workers resulted in quality problems, workers not doing what they were supposed to do, an unhealthy relationship between the workers and management and the continual disruption of production.
- E. The lack of capital limited growth.
- F. The lack of capital caused delays in production, as the business could not afford to purchase raw materials required for manufacture.
- G. Poor cash flow into the business resulted in management stress.

Figure 53: Severity of Problems Caused by the Lack of Resources and skills shows the percentage of respondents who encountered these problems in managing their businesses.

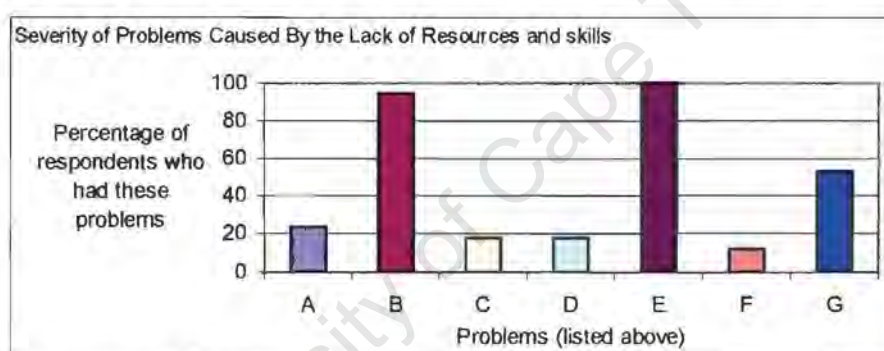


Figure 53: Severity of Problems Caused by the Lack of Resources and skills

From question 42: Response to the open-ended question 42, where the respondents were asked to describe what they believed to be causes, other than those described previously in the questionnaire, of late deliveries, substandard product quality and increased operating costs revealed both previously unnoticed undesirable effects as well as some root causes. The undesirable effects that were identified were,

- A. Management spent an excessive amount of time dealing with labour disputes.
- B. Production time was lost to strikes and go-slows.
- C. The business was able to purchase only limited quantities of cheap machinery and equipment of questionable quality.
- D. The business was unable to attract skilled and experienced staff.

E. Workers did not give their best effort consistently.

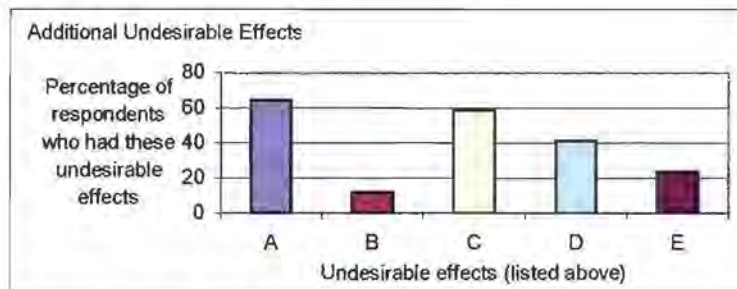


Figure 54: Additional Undesirable Effects

Respondents stated the following to be some of the root causes of the undesirable effects identified in this section.

- The business was unable to obtain sufficient working capital or finance for growth as lending institutions required excessive collateral and offered finance at extremely high lending rates.
- Management had extremely set mental models (paradigms).
- Management lacked the necessary knowledge and expertise to manage all aspects of their businesses effectively.

8 SMALL BUSINESS MANUFACTURING SYSTEM CURRENT REALITY

TREE:

The definition of a theory, as discussed in section 3.1 The Nature and Theory of Research, is represented in the form of a current reality tree, where the undesirable effects and causes are the “concepts” and the links between them the “causal relationships”.

8.1 Construction of the Current Reality Tree:

The process of identifying root causes responsible for the undesirable effects in manufacturing systems of small businesses, listed later in this section, and for constraining the overall performance of the manufacturing system, was based on Goldratt’s effect-cause-effect methodology.

Constructing the chains of hypothesised effects-cause-effects relationships to form the current reality tree began by focusing on one prevalent undesirable effect, for example, poor due-date performance of the manufacturing system. A cause directly responsible for this undesirable effect was then proposed, for example, the direct cause of the undesirable effect above was proposed to be - actual delivery dates exceeds promised delivery dates. Identifying another effect of the proposed cause, called a verifying effect then validated the proposed cause. For example, a verifying effects of the above proposed cause was - promised delivery = 2 to 3 weeks from order date while actual delivery = 6 to 8 weeks from order date. The proposed cause was then treated as an intermediate effect and a direct cause was proposed for its presence and so on. The generic step-by-step process presented in Figure 55: Effect-Cause-Effect Methodology continued until a root cause was identified. This process relies on intuition and an extremely detailed understanding of the system being analysed.

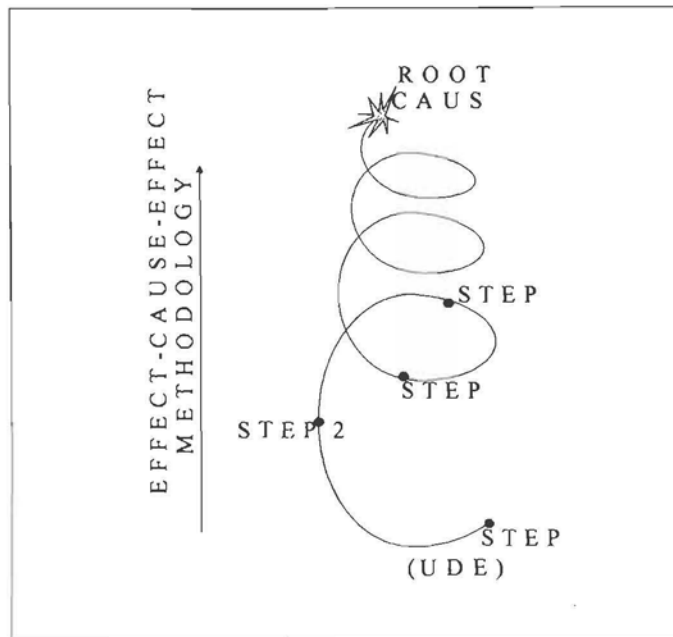


Figure 55: Effect-Cause-Effect Methodology

Dettmer [50] stated that the strength of the current reality tree lay in its capability to trace a clear chain of causal links from a series of undesirable effects to a core problem or a few root causes. The construction process therefore had to consist of incremental logical focused steps that prevented big leaps in logic and leaps from one causal chain to another to ensure its effectiveness.

In addition to avoiding big leaps in logic, Dettmer [51] proposed adding a passive condition and passive cause to each active root cause, where the passive condition provided the environment in which the active cause could exist and the passive cause was the failure to intervene. Together with the active root cause, the policy driving the undesirable effect, the passive cause and condition show the steady state response of the system to the policy and can therefore be used to predict the future to aid in decision making. Furthermore, Dettmer [52] stated that effects that made up part of the current reality tree should not be characterised by judgmental assessments as their presence would under normal current reality tree construction conditions create logic deficiencies. Characterising an effect with some type of judgmental assessment, for example, excessive or insufficient, results in a lack of clarity, as there is no reference to compare the assessment. The model constructed for this project is however, a general model that

can be used to represent the basic effect-cause-effect relationships in any small manufacturing business conforming to the set conditions and therefore cannot be too specific.

8.2 Categorising the Undesirable Effects Identified:

The four most basic undesirable effects identified through personal experience, through discussions with other production managers of small manufacturing businesses, through the literature surveyed and through the survey questionnaire, related to the 'manufacturing quality' of the business's manufacturing systems. These undesirable effects were,

- ude1. The final product quality was inconsistent or substandard.**
- ude2. The due date delivery performance of the manufacturing system was poor.**
- ude3. Production costs were excessively high.**
- ude4. The responsiveness and flexibility of the manufacturing system was poor.**

The majority of the other undesirable effects identified, listed below, are intermediate effects between these four basic undesirable effects and their root causes. These intermediate effects have been categorised according to the following key areas.

- Management related undesirable effects:
- Production workforce related undesirable effects:
- Inventory related undesirable effects:
- Product and work quality related undesirable effects:
- Purchasing and supplier related undesirable effects:
- Production scheduling related undesirable effects:
- Production workflow and material handling related undesirable effects:
- Machinery and equipment related undesirable effects:
- Working capital and cash flow related undesirable effects:

Category 1. Management related undesirable effects:

ude 4. Management productivity is low

- ude 5. Management must often perform physical tasks in manufacturing process
- ude 6. Excessive management time is spent supervising workers
- ude 7. The same problems arise repeatedly in the manufacturing system
- ude 8. Management does not have sufficient time to cover all their function and tasks effectively
- ude 9. Excessive management time is spent dealing with labour disputes
- ude 10. Excessive management time is spent retraining workers
- ude 11. Excessive management time is spent training newly employed production workers
- ude 12. Excessive management time is spent inspecting the quality of work produced in the manufacturing system

Category 2. Production workforce related undesirable effects:

- ude 13. Production workers are constantly making mistakes
- ude 14. Morale of the production workforce is low
- ude 15. Production workers are dissatisfied with the work they perform
- ude 16. The production workforce lacks the necessary skills to perform their tasks correctly
- ude 17. There is a lack of qualified staff to train newly employed workers or already employed workers for new tasks
- ude 18. There is a high production worker turnover-rate
- ude 19. There is a high rate of production worker absenteeism
- ude 20. Production workers disregard or ignore instructions, rules, correct standard working procedures and methods and set working times
- ude 21. Production workers do not adhere to standard work procedures and or methods
- ude 22. Production workers lose their concentration easily
- ude 23. Production workers get bored easily
- ude 24. Production workers are constantly milling around or disturbing one another when unsupervised
- ude 25. Workers are constantly arriving late for work

Category 3. Product and work quality related undesirable effects:

- ude 26. There is an excessive amount of substandard or defective goods produced
- ude 27. Defects or quality problems are only noticed late in the manufacturing process or as goods are about to be despatched
- ude 28. Finished goods are damaged while in storage
- ude 29. Quality of the work varies from one batch to another of the same item
- ude 30. Work performed is not to standard or is inconsistent

Category 4. Purchasing and supplier related undesirable effects:

- ude 31. The quality of raw materials and outsourced parts is not to the desired or required standard of quality
- ude 32. Deliveries by suppliers are constantly late or their lead times are excessively long
- ude 33. Excessive management time is spent chasing suppliers
- ude 34. Suppliers hold back deliveries
- ude 35. Raw materials, parts and consumables are often not ordered in time

Category 5. Production scheduling related undesirable effects:

- ude 36. Excessive delays in production cause lead times to exceed promised delivery dates
- ude 37. The production schedule is constantly being disrupted
- ude 38. The production schedule requires constant re-planning
- ude 39. Workers are idle while waiting for necessary tools and equipment to perform their tasks
- ude 40. Unplanned additional work is required to correct or replace substandard materials and parts
- ude 41. An excessive amount of management time is spent expediting work
- ude 42. There is an excessive amount of production time lost
- ude 43. Unnecessary overtime is constantly required
- ude 44. Changeover times are long

Category 6. Production workflow and material handling related undesirable effects:

- ude 45. Parts and or materials are not always ready when required
- ude 46. Waiting time of batches between workstations is excessively long
- ude 47. Workers are constantly wondering around looking for missing parts
- ude 48. There is excessive handling of raw materials, parts, work-in-process and finished goods
- ude 49. Goods are mishandled while in transit and in storage
- ude 50. Materials, parts, work-in-process and finished goods disrupt the flow of work through the manufacturing system
- ude 51. The factory is always untidy

Category 7. Inventory related undesirable effects:

- ude 52. There is a large amount of unfinished items awaiting out-of-stock parts
- ude 53. There is excessive amount of raw materials, parts, work-in-process and finished goods in stock
- ude 54. There is a build-up of work-in-process at certain points in the manufacturing process
- ude 55. Raw materials, parts, work-in-process and finished goods are constantly misplaced while in transit between operations or in storage

Category 8. Machinery and equipment related undesirable effects:

- ude 56. Machinery and equipment is old and in poor condition
- ude 57. There is a lack of spare machinery and equipment to use while breakdowns occur
- ude 58. Workers do not know how to use the machinery and equipment correctly
- ude 59. Workers abuse the machinery and equipment
- ude 60. Machinery and equipment breakdown frequently

Category 9. Working capital and cash flow related undesirable effects:

- ude 61. There is a lack of working capital
- ude 62. Excessive capital is tied up in the manufacturing system

- ude 63. The business cannot make or does not make timely payments to suppliers
- ude 64. Implementation of new technology is severely limited
- ude 65. The business cannot afford to replace or recondition old and worn machinery
- ude 66. The business cannot afford to purchase the required suppliers for production

8.3 Small Business Manufacturing System Current Reality Tree:

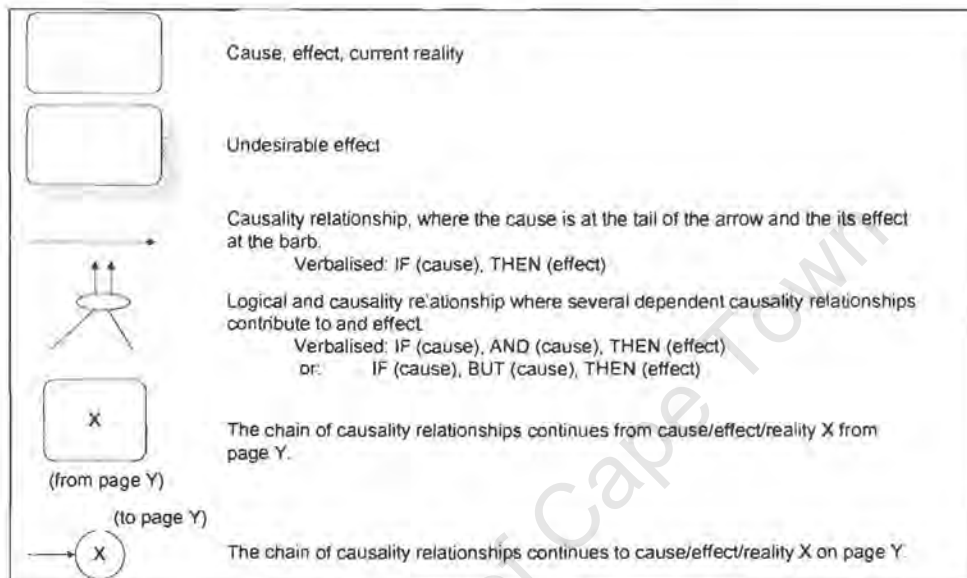


Figure 56: Current Reality Tree (CRT) Symbolology

The following 17 pages contain the Small Business Manufacturing System Current Reality Tree.

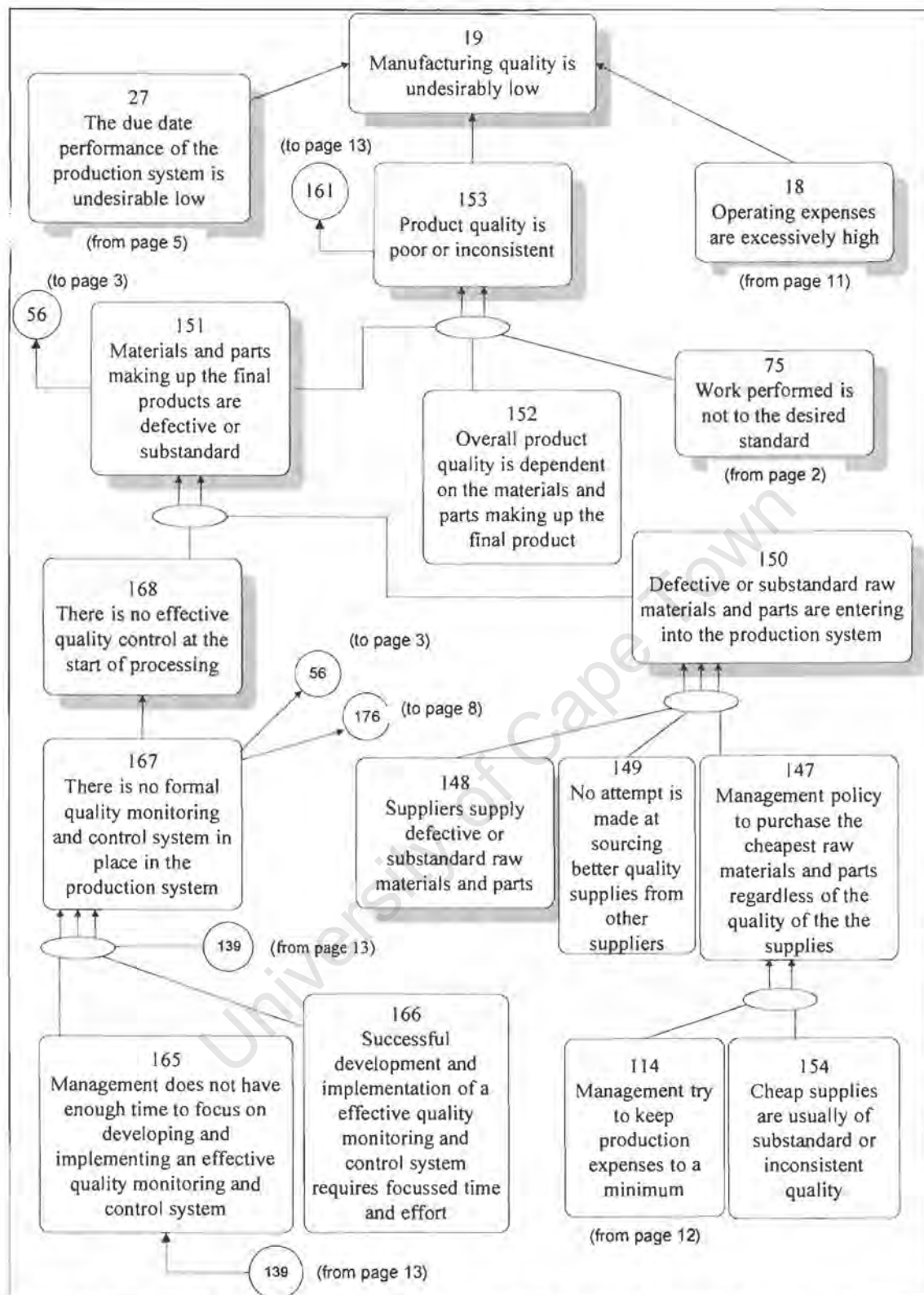


Figure 57–page 1: Small Business Manufacturing System Current Reality Tree.

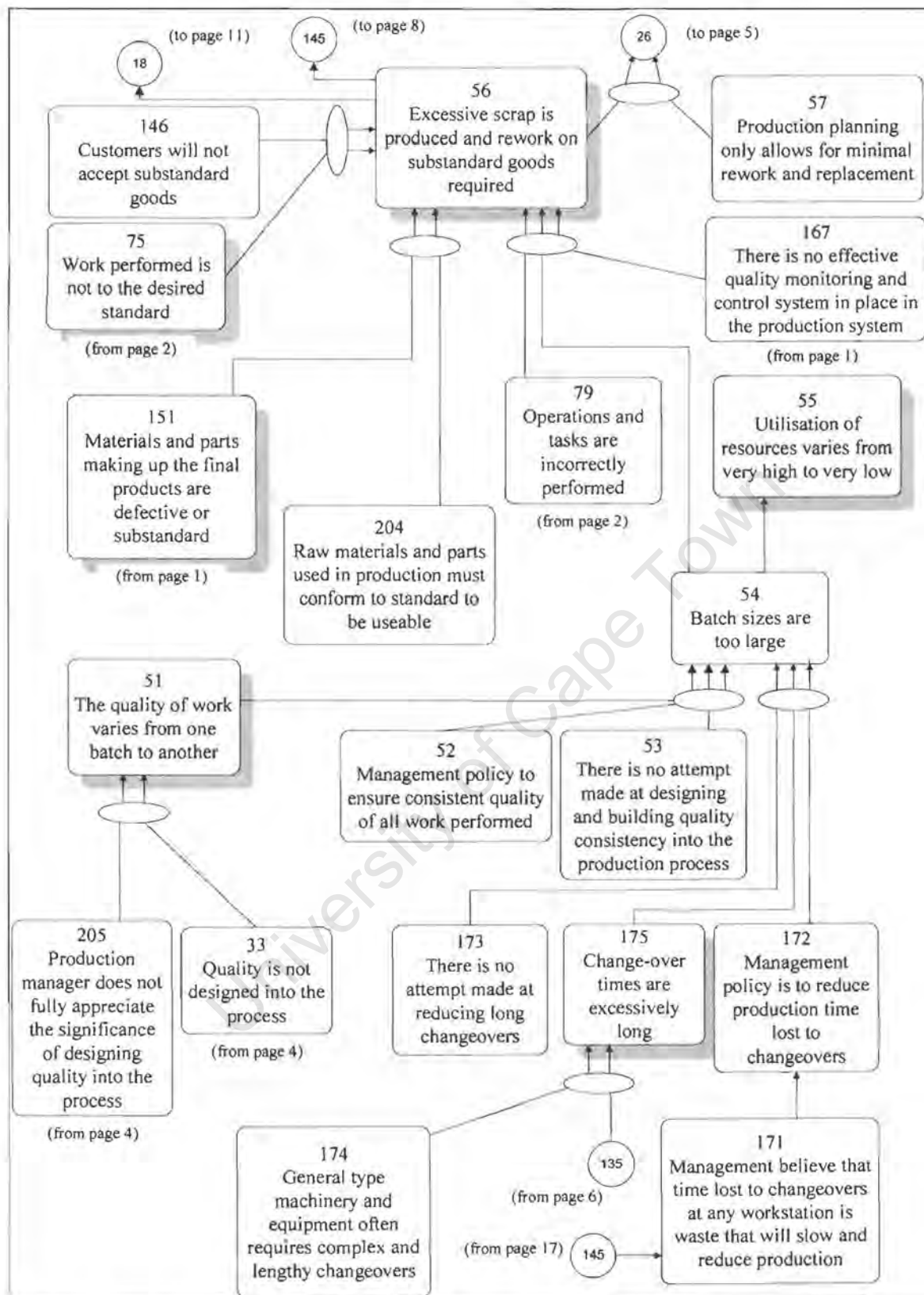


Figure 55—page 3: Small Business Manufacturing System Current Reality Tree.

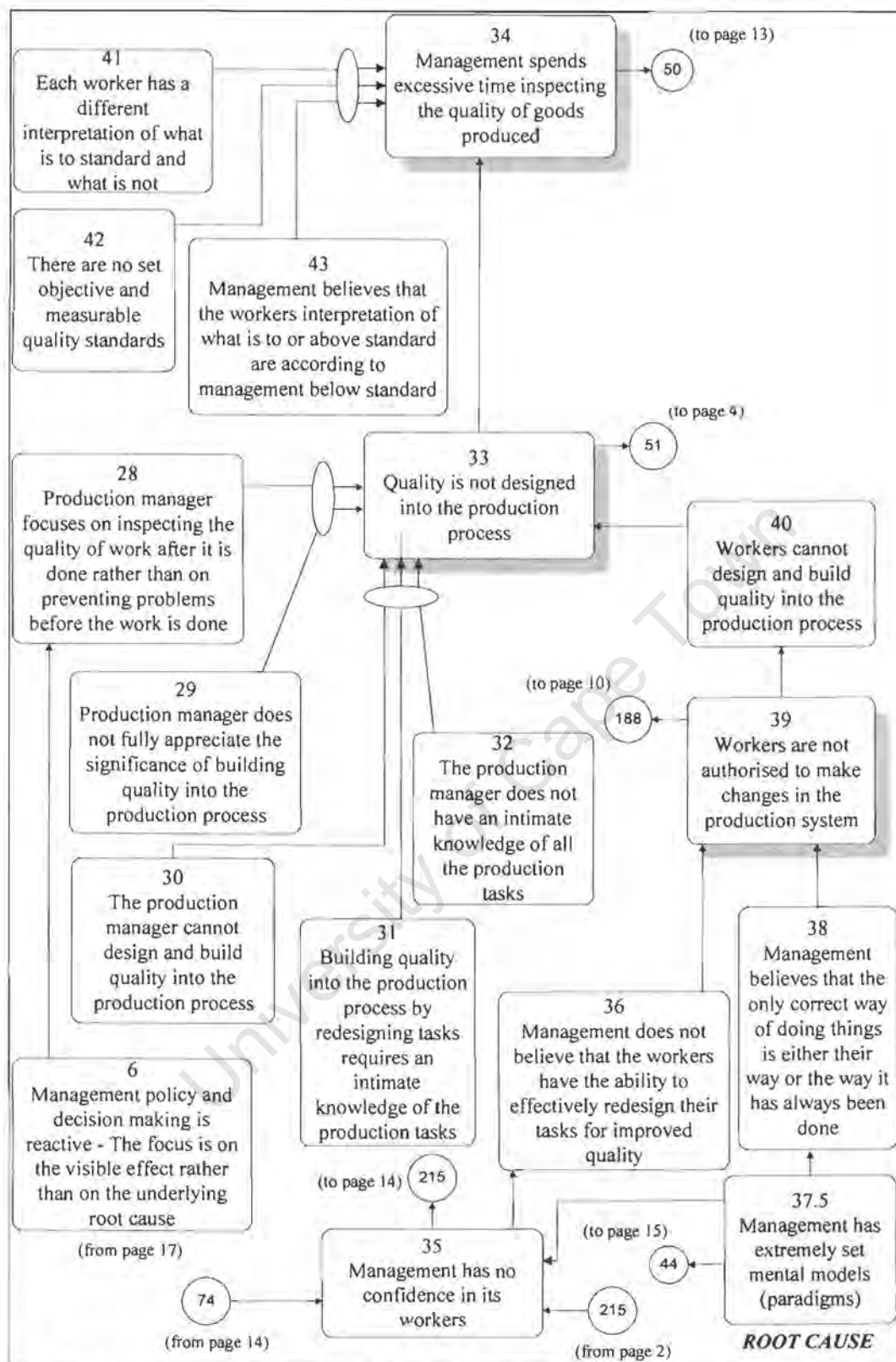


Figure 55–page 4: Small Business Manufacturing System Current Reality Tree.

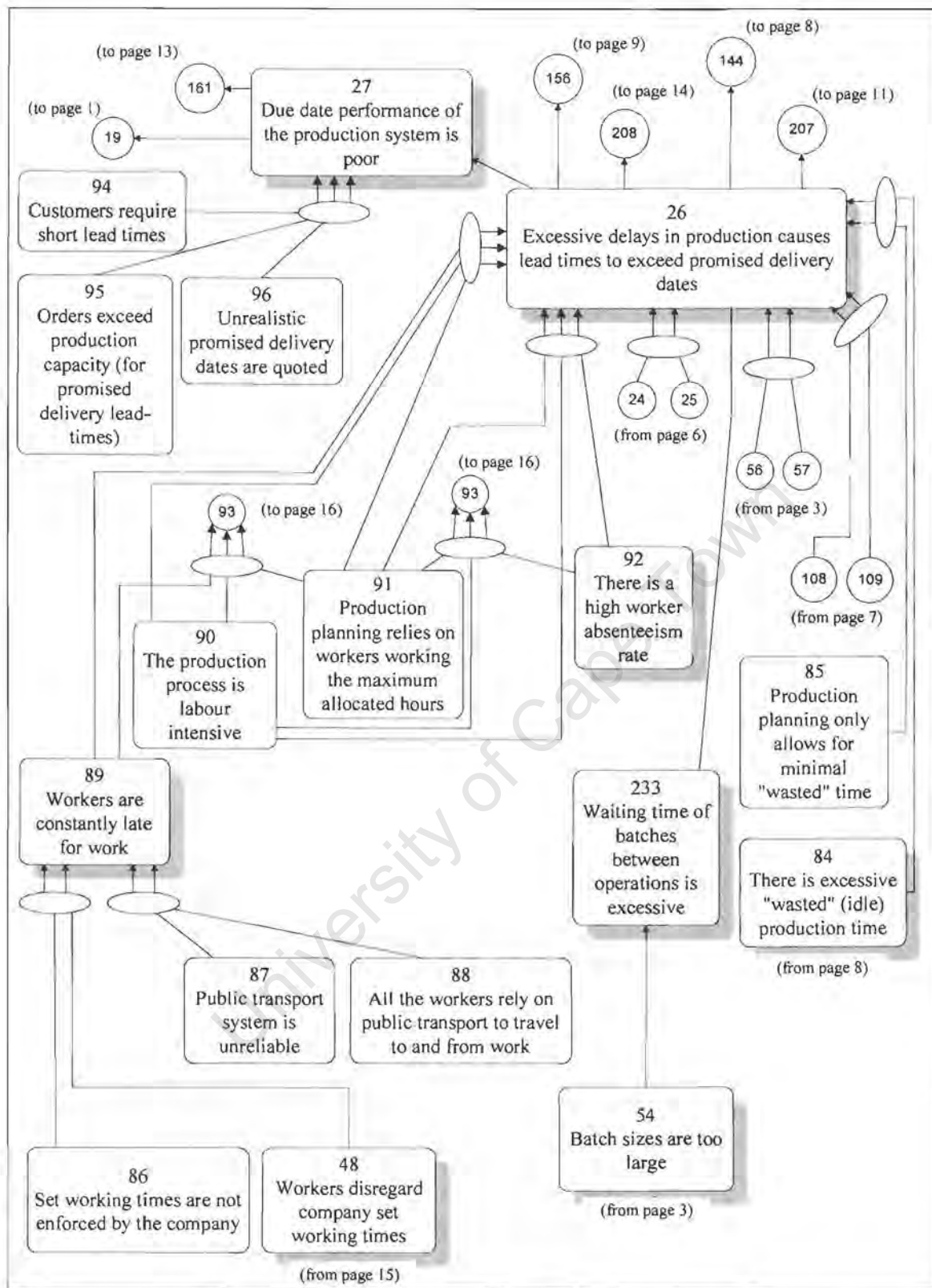


Figure 55—page 5: Small Business Manufacturing System Current Reality Tree.

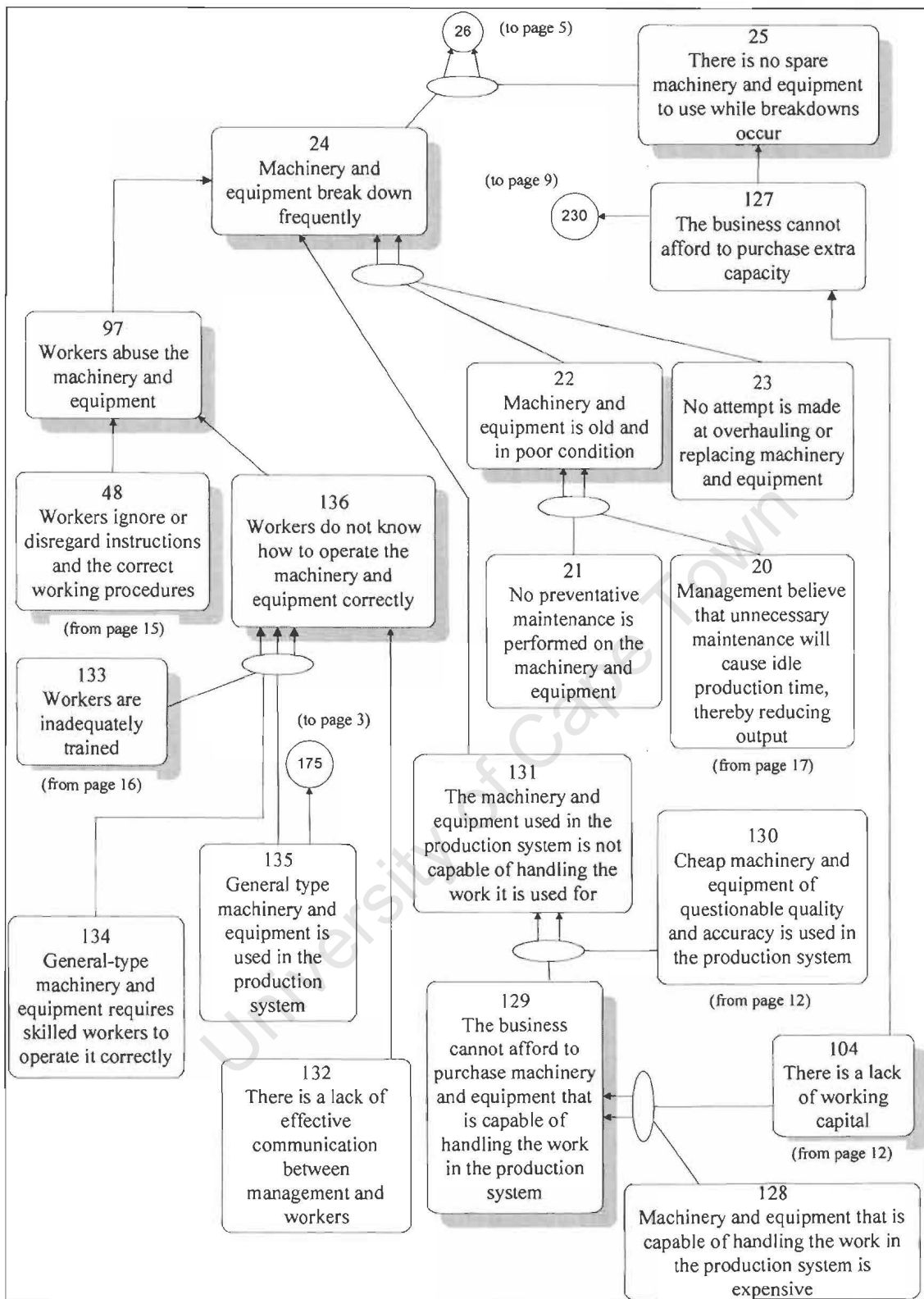


Figure 55—page 6: Small Business Manufacturing System Current Reality Tree.

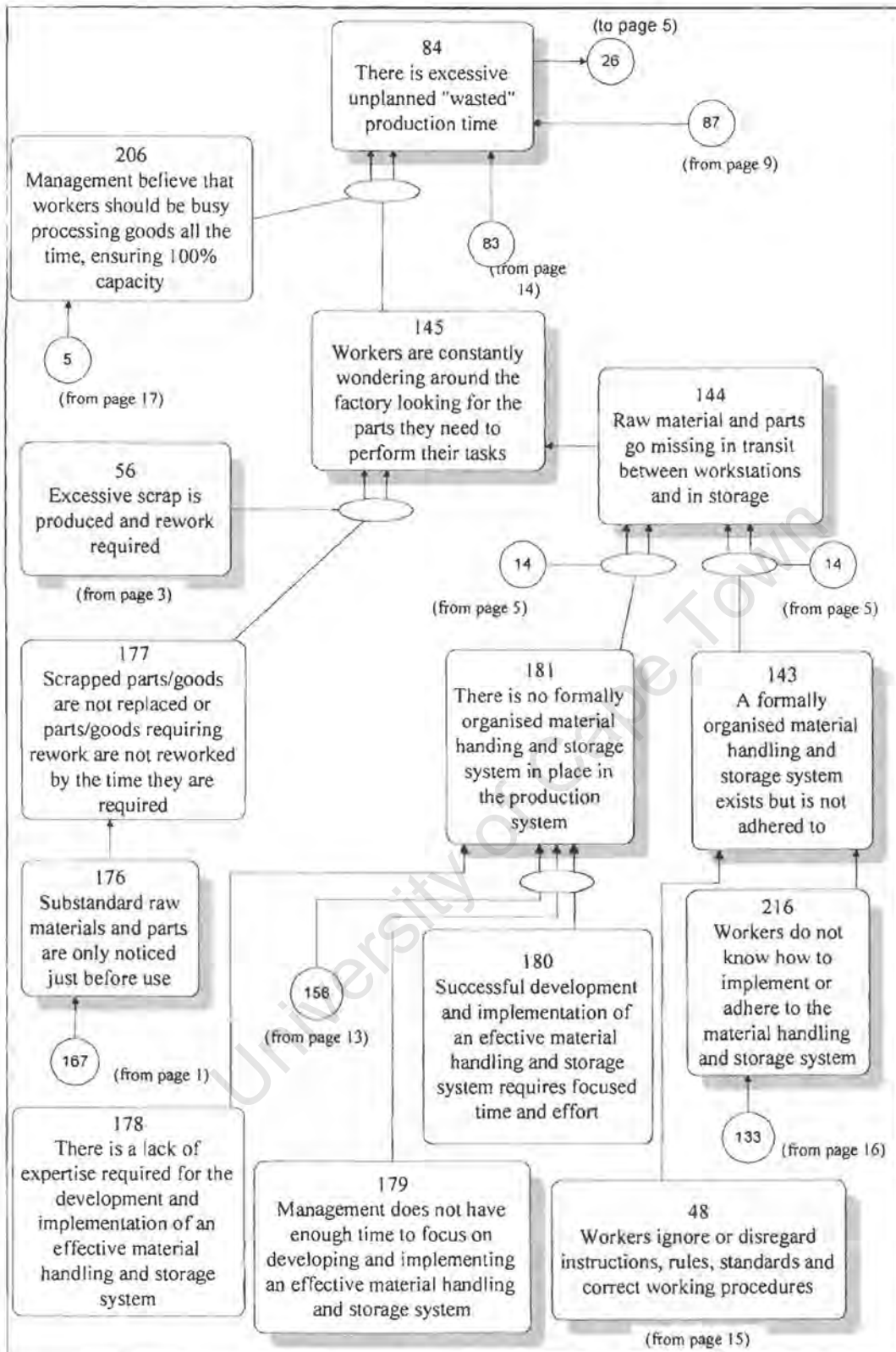


Figure 55–page 8: Small Business Manufacturing System Current Reality Tree.

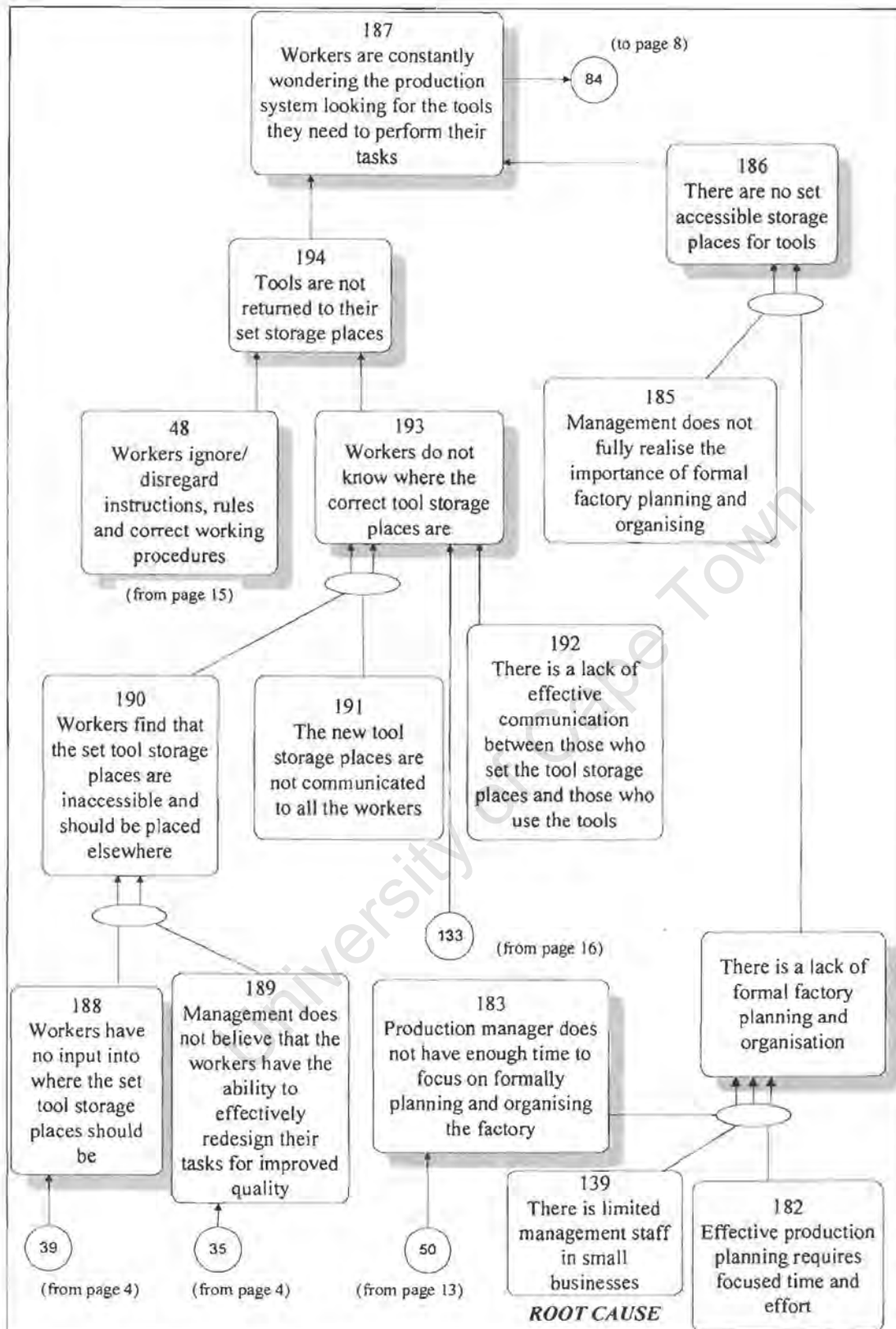


Figure 55—page 10: Small Business Manufacturing System Current Reality Tree.

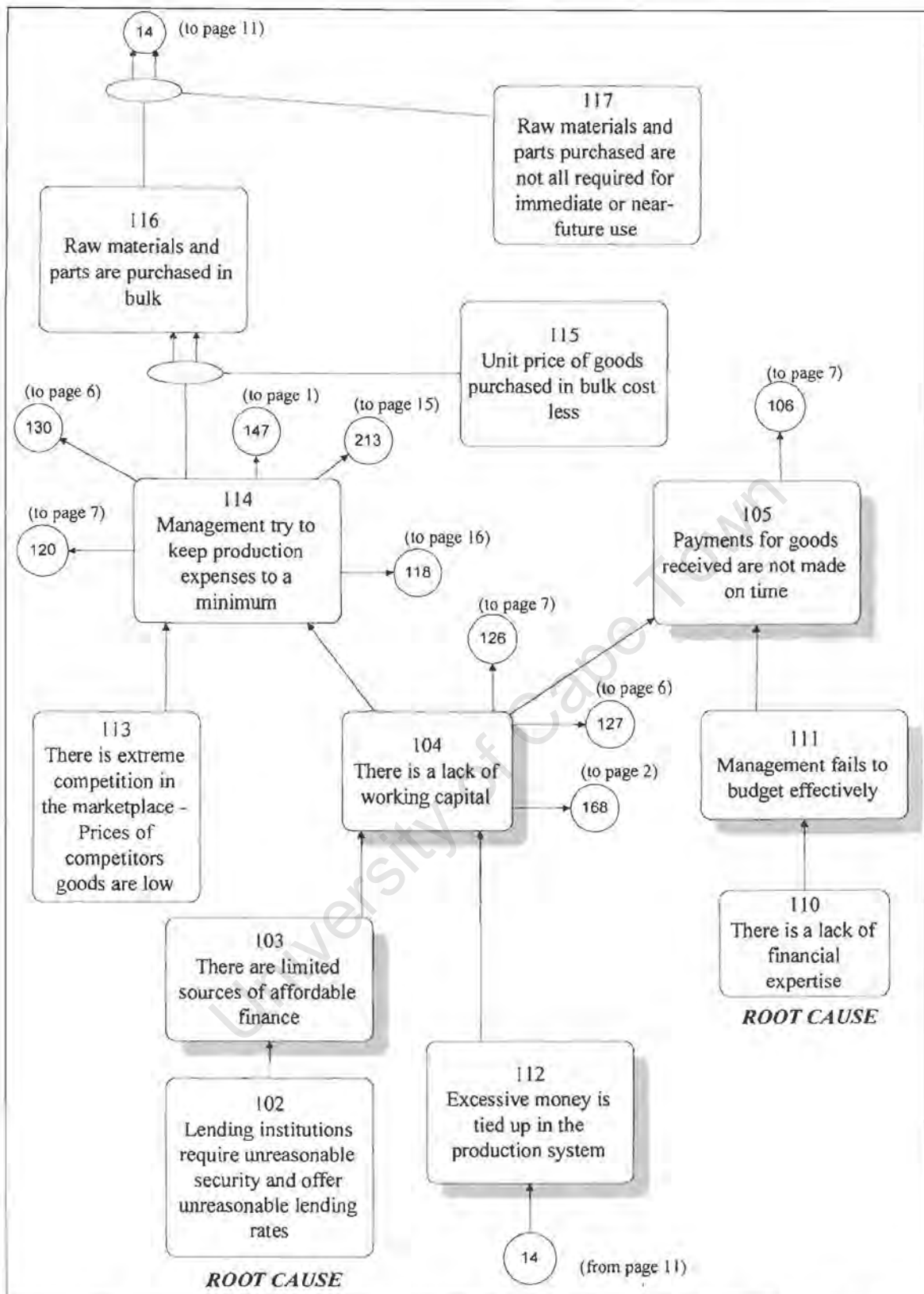


Figure 55—page 12: Small Business Manufacturing System Current Reality Tree.

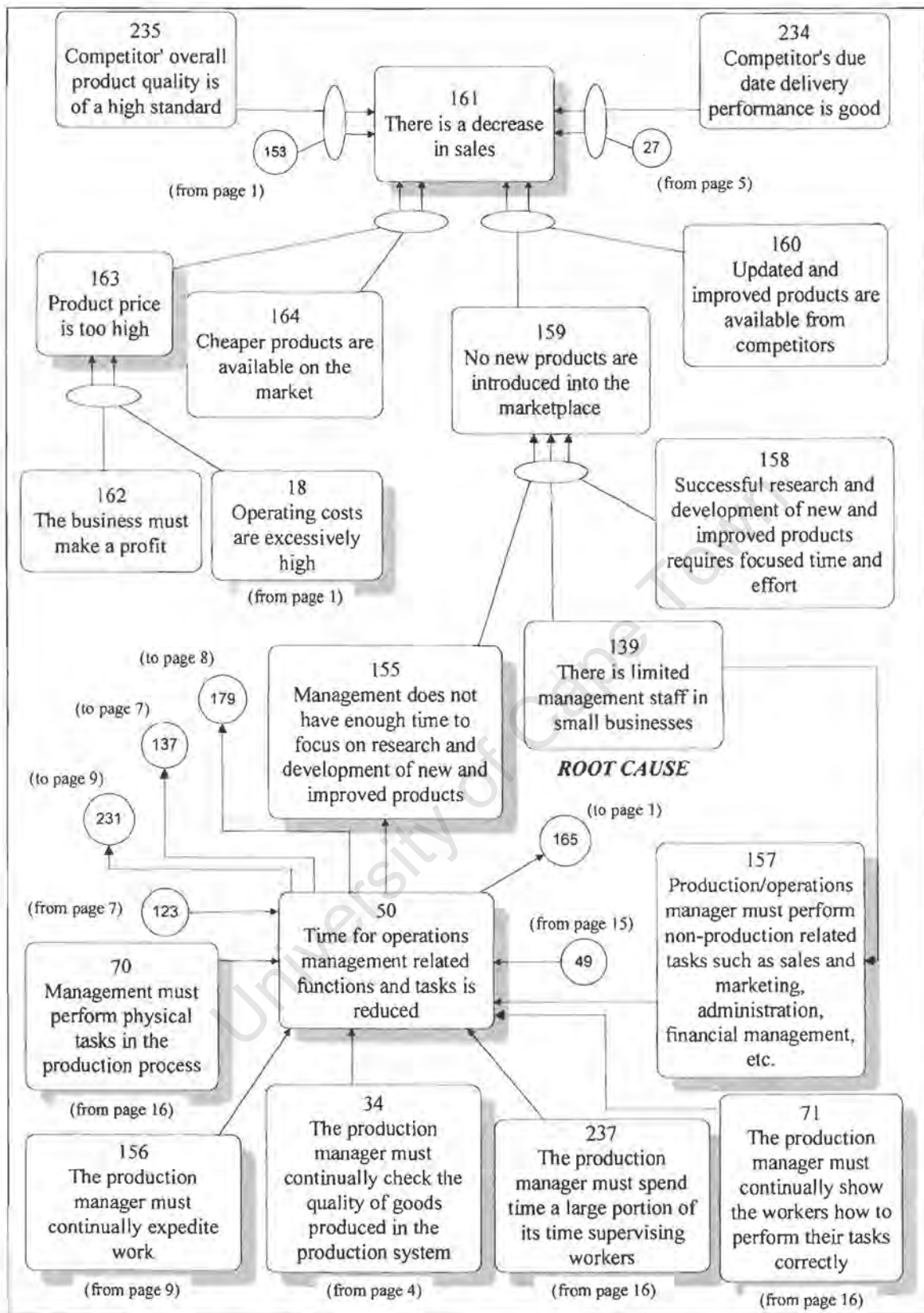


Figure 55—page 13: Small Business Manufacturing System Current Reality Tree.

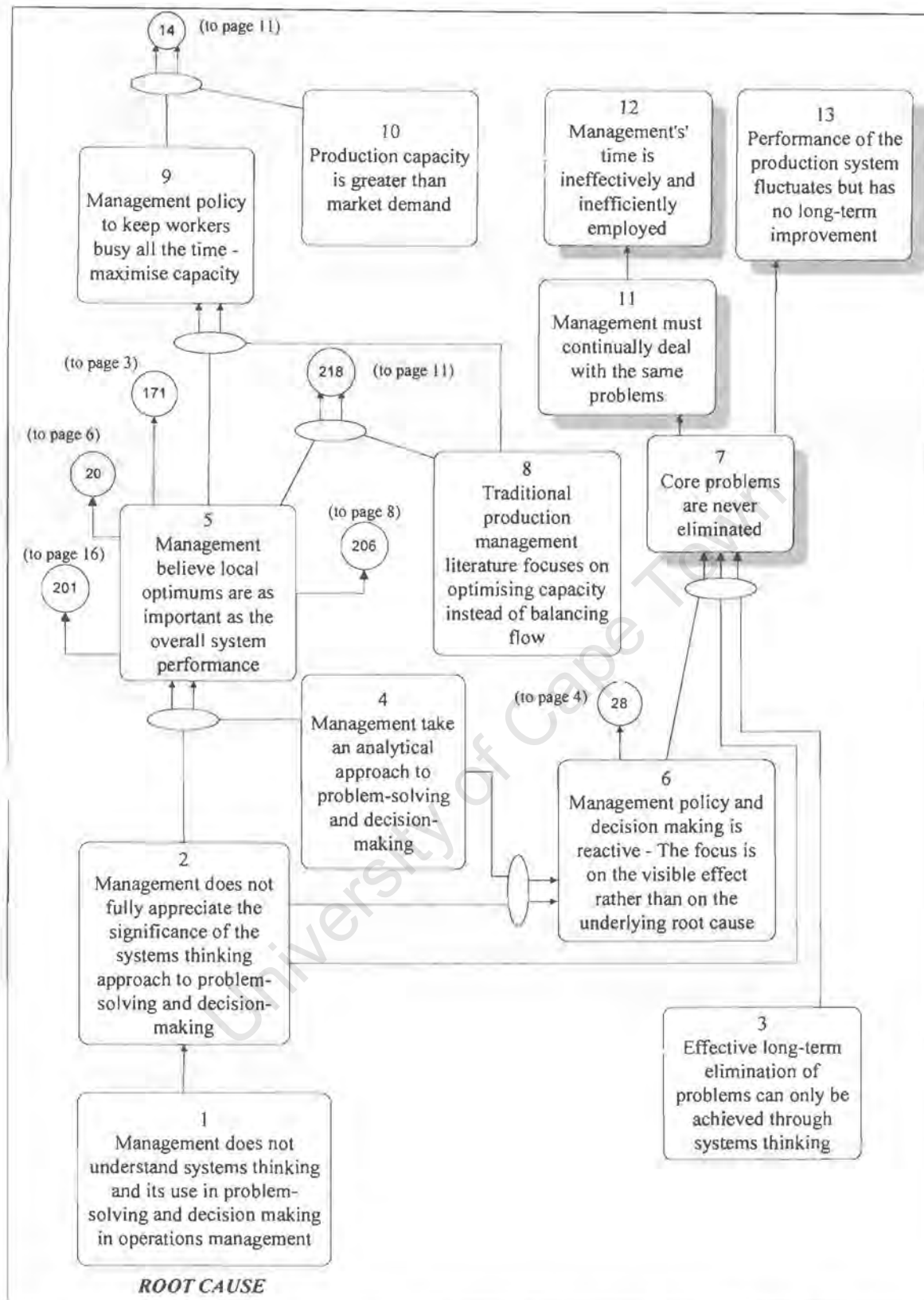


Figure 55–page 17: Small Business Manufacturing System Current Reality Tree.

8.4 Checking the Logicality of (“Drying Out”) the Current Reality Tree:

In contrast to traditional problem-solving tools, such as flowcharts and “fishbone” diagrams, the Theory of Constraints thinking process is composed of logical tools rather than perceptions of relationships. A set of rules or tests of logic was therefore required for the construction and review of the trees. Goldratt [53] states that there are seven rules or tests that every effect-cause relationship making up the tree must pass for the tree to be “logically sound”. These rules or tests are known as the Categories of Legitimate Reservations.

- Entity Existence
- Causality existence
- Tautology
- Predicted Effect Existence
- Cause Insufficiency
- Additional Cause
- Clarity

These rules were used to test the logicality of the Current Reality Tree in the following ways.

1. Entity Existence: Every entity (effect or cause) was checked to ensure they were valid, complete and structurally correct.
2. Causality existence: If-then connections were used to ensure that the relationship connections between every effect and cause were valid.
3. Tautology: Intangible causes were substantiated with additional direct verifiable effects.
4. Predicted Effect Existence: The presence of additional effects of every cause was checked to ensure that the validity of the original effect was not negated.
5. Cause Insufficiency: The proposed cause or causes in every effect-cause relationship were checked to be sufficient to have the effect. The function of the ellipses shown in the current reality tree was to enclose the major contributing causes that were sufficient in concert but not alone to produce the effect.

6. Additional Cause: Additional causes were added to the effect-cause relationships wherever it magnified the effect. In contrast to the cause insufficiency case, if one of the additional causes were removed the effect remained valid.
7. Clarity: If-then connections were used to check the clarity of every effect-cause relationships. As one of the purposes of the trees presented in this project was to communicate the proposed effect-cause relationships, the trees had to be clear.

The seven categories of legitimate reservation were later used to test the logicity of the Future Reality Tree.

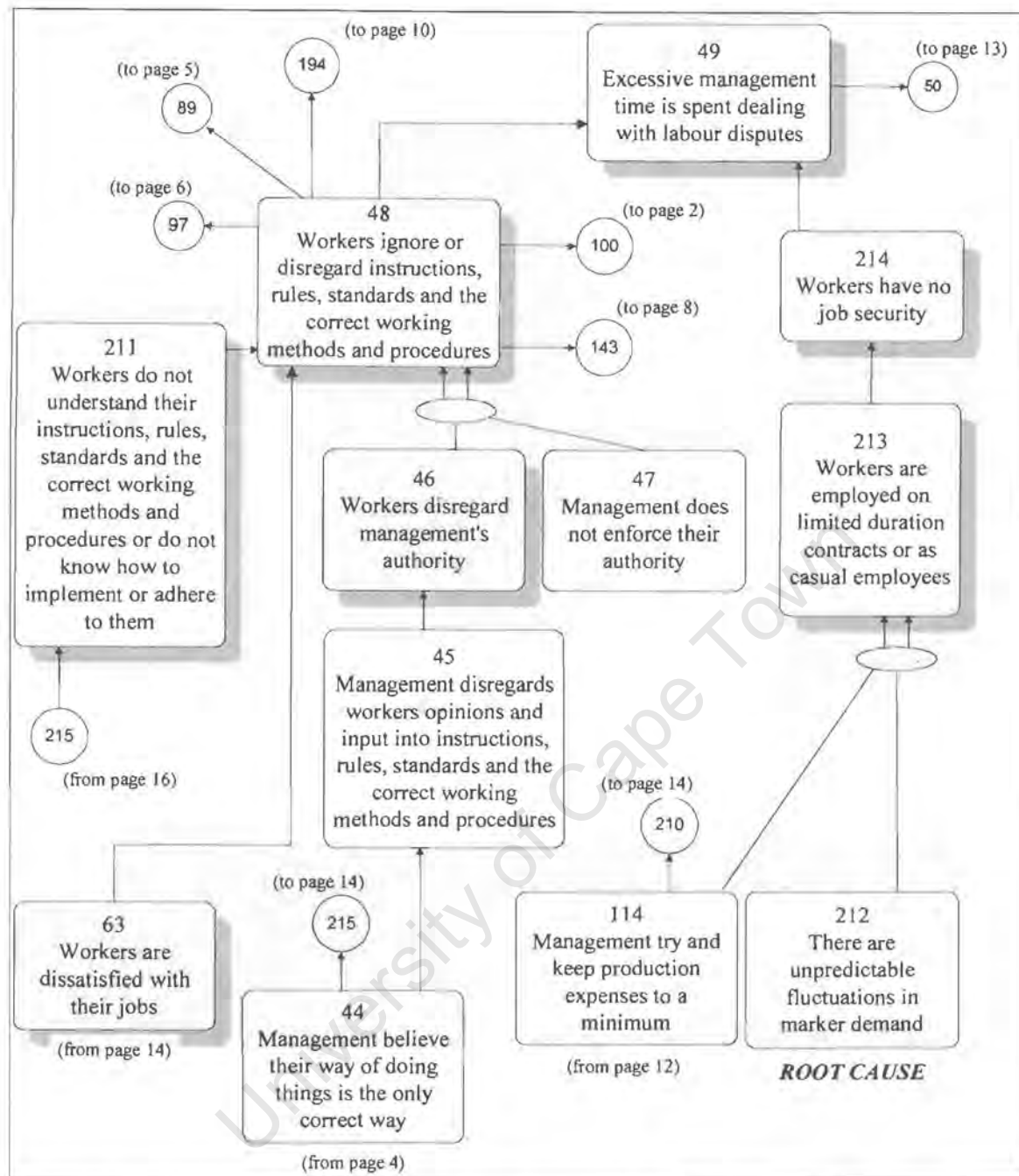


Figure 55—page 15: Small Business Manufacturing System Current Reality Tree.

9 CONFLICT IDENTIFICATION & RESOLUTION:

The conflict resolution diagram, or evaporating cloud, was used to answer the first part of the second question “what to change to?” The basic assumption validating the use of the conflict resolution diagram was that most core problems existed because there was some type of underlying conflict that prevented the generation of straightforward solutions to the problems. In these instances compromises were made that perpetuated the problem.

9.1 Conflict Resolution Diagrams:

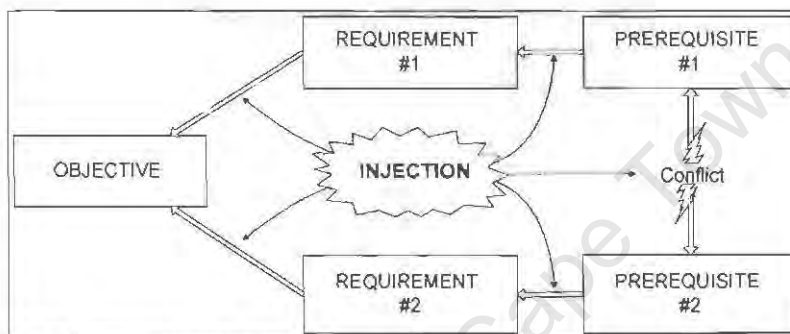
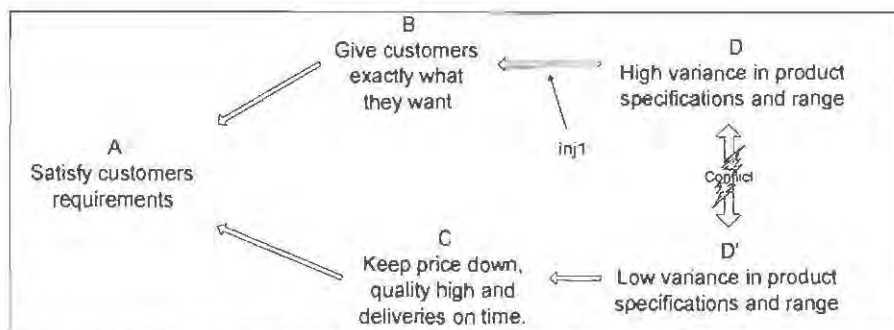


Figure 56: The Conflict Resolution Diagram

The strength of the conflict resolution diagram lies in the underlying assumptions behind the logical relationships between the prerequisites and requirements, the requirements and objectives and the conflicting prerequisites. Some of these underlying assumptions although accepted as being valid are usually questionable and are subject to invalidation through the input of injections (an initiated change). Invalidating the assumptions opens up opportunities for resolving the conflict. The injections proposed for breaking the conflict situations described in this section are either specific actions or desirable conditions (where a complex set of actions were necessary) that were required to either invalidate questionable assumptions or bypass valid assumptions. All the proposed injections were therefore things that did not exist and had to happen to break the conflict.

The following conflict resolution diagrams were used to define precisely the core problems that were uncovered through the development of the current reality tree and through the identification of opposite conditions (prerequisites that are mutually

exclusive) or different alternatives (never enough resources to do both) in managing manufacturing systems of small businesses.



Conflict Resolution Diagram 1: Resolving conflict between high and low variance in product specification and range.

Assumptions D' → C:

1. A high variance in product specification will result in production difficulties and subsequently increased manufacturing costs, inconsistent quality and overdue deliveries.
2. A system in which goods with low variance in specifications and range are produced requires fewer changeovers, fewer skills and less equipment and results in more stable production than systems in which goods with a high variance in specification and range are produced.

Assumptions D → B:

1. Customers have varying requirements.

Assumptions B → A:

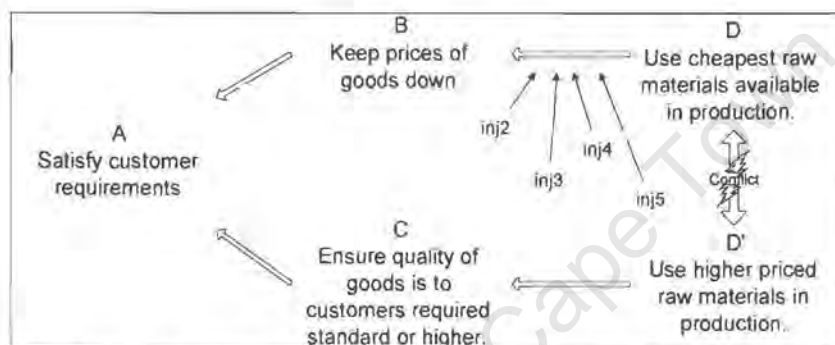
1. Larger businesses can offer better prices, more consistent quality and better due-date delivery, therefore small businesses must focus on offering a more "customerised" service in order to attract and sustain customers.
2. The actions and activities that are required for giving customers exactly what they want are different to those required for keeping product prices down, quality acceptable and deliveries on-time.
3. Customers will only purchase goods if they are needed and if they are usable.

Assumptions C → A:

1. Customers will only purchase goods if the price is right, the quality acceptable and delivered when required.
2. The actions and activities that are required for keeping product prices down, quality acceptable and deliveries on-time are different to those required for giving customers exactly what they want.

Injects:

Inj-1: Flexibility must be designed into the products and the process in which they are produced.



Conflict Resolution Diagram 2: Resolving conflict concerning the price of raw materials used in the manufacturing system.

Assumptions D' → C:

1. The more expensive the raw material the better the quality.
2. The quality of the goods produced is directly dependent on the quality of raw materials used in its production.

Assumptions D → B:

1. There are no alternative ways of reducing the cost of producing goods other than by reducing the cost of the raw materials used in the goods and the consumables used to make the goods.
2. More costly raw materials cannot be purchased due to the lack of working capital.
3. There are other means of reducing manufacturing costs other than by reducing the cost of raw materials.

Assumptions B → A:

1. Competitors are constantly reducing the price of their products, which means that we must follow suit.

Assumptions C → A:

1. Reducing the cost of products sold and ensuring its quality remains as per customer requirement cannot be achieved simultaneously.
2. The marketplace is filled with similar goods. Attracting customers can therefore only be achieved by selling the goods that are to or above the level of quality required or specified by the customers.
3. The actions required for reducing the manufacturing costs are different from those required for ensuring consistent and high quality products.

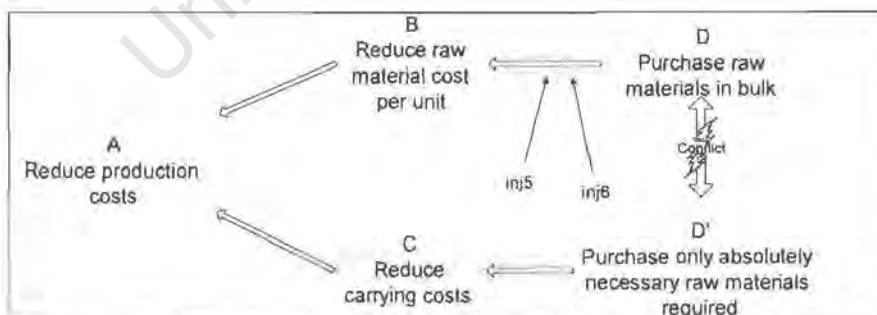
Injections:

Inj-2: Freed up capital from quicker inventory turnover (time between paying for goods received and receiving payment for goods shipped) can be used for purchasing better quality raw materials.

Inj-3: Have quality inspection in front of the first operation to ensure that no substandard material is used in the process.

Inj-4: Redesign the products and the process in which they are produced to use alternative raw materials.

Inj-5: Form buying partnerships with other similar businesses or have long term contracts with suppliers to purchase better quality goods at reduced prices.



Conflict Resolution Diagram 3: Resolving conflict between purchasing raw materials in bulk or purchasing only necessary raw materials required.

Assumptions $D' \rightarrow C$:

1. Purchasing only the necessary raw materials prevents the build up of inventory.
2. Holding unnecessary inventory means that money is tied up in the manufacturing system.
3. With rapidly changing market requirements inventory can become obsolete quickly.

Assumptions $D \rightarrow B$:

1. There are no alternative ways of reducing the cost of producing goods other than by reducing the cost of the raw materials used in the goods and the consumables used to make the goods.
2. The unit price of goods purchased in bulk costs less.

Assumptions $B \rightarrow A$:

1. The marketplace is filled with similar goods. Attracting customers can therefore only be achieved by selling the cheapest goods.
2. Material costs makes up a large portion of the overall product cost.

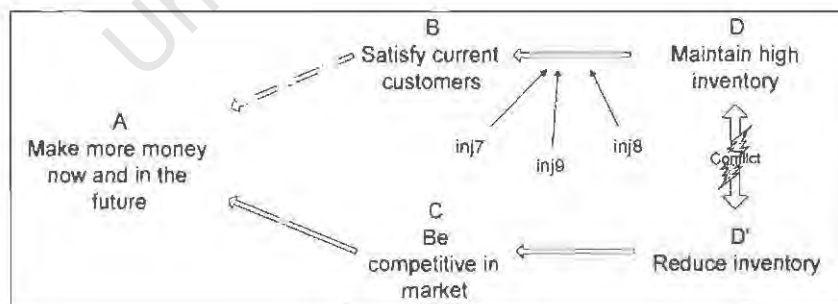
Assumptions $C \rightarrow A$:

1. Cost of carrying inventory adds to manufacturing costs and reduces working capital.

Injections:

Inj-5: Form buying partnerships with other similar businesses or have long term contracts with suppliers to purchase supplies in small quantities at reduced prices.

Inj-6: Use fewer raw materials by reducing waste. For example, determine the most efficient way of cutting the raw material to size with the least amount of waste.



Conflict Resolution Diagram 4-a: Resolving conflict between concerning the optimum level of inventory.

Assumptions D' → C:

1. High inventory results in excessive capital tied up in manufacturing that could be more effectively used for things like; new product development, expanded marketing and sales, modernisation of the plant, re-engineering the manufacturing system and debt reduction.
2. High inventory requires excessive space for storage, space that could be used more effectively.
3. High inventory of work-in-process in the manufacturing system and finished goods in storage disrupts the smooth flow of and creates additional work (constantly have to move inventory around).
4. With rapidly changing market requirements inventory can become obsolete quickly.

Assumptions D → B:

1. Customers require short production lead times.
2. There are no alternative ways of reducing lead times other than by holding inventory.

Assumptions B → A:

1. Satisfying the current customers' needs is more important than expanding the business or attracting new customers.

Assumptions C → A:

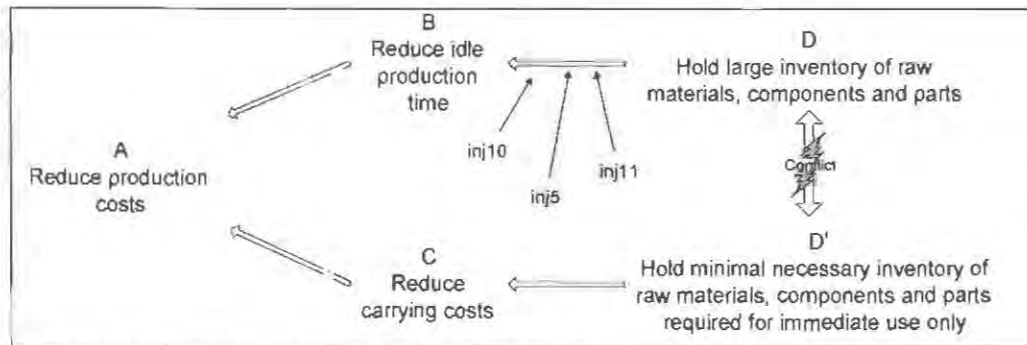
1. Being competitive by offering overall service that is better than the competitor service is essential for achieving the business goal.

Injectors:

Inj-7: Differentiate between transfer and process batches.

Inj-8: Implement a drum-buffer-rope pull-type production scheduling system.

Inj-9: Have larger process batch sizes at bottleneck operations and smaller process batches at non-bottleneck operations. If the process batch size at a non-bottleneck operation is too small then it will become a bottleneck.



Conflict Resolution Diagram 5-b: Resolving conflict between concerning the optimum level of inventory.

Assumptions D' → C:

1. The changing and dynamic market results in constant product changes making inventory obsolete.
2. Holding inventory of raw materials, components and parts that will not be used immediately results in more capital than necessary being tied up in the manufacturing system.
3. Lower levels of inventory require less storage space.
4. Not all suppliers are unreliable or have long lead-times.

Assumptions D → B:

1. Current supplier's deliveries are always late or their lead times are excessively long.
2. There are no alternative ways of ensuring that raw material, components and parts are ready when required other than by holding inventory.
3. Raw material, components and parts in stock will all eventually be used.

Assumptions B → A:

1. Idle time "costs" money.
2. There are no alternative ways of reducing idle time other than by ensuring that there is always work to be processed.
3. Maintaining high utilisation of workers and equipment is more important than reducing carrying costs.
4. The actions that are required for reducing idle time are different to those required for reducing carrying costs.

Assumptions C → A:

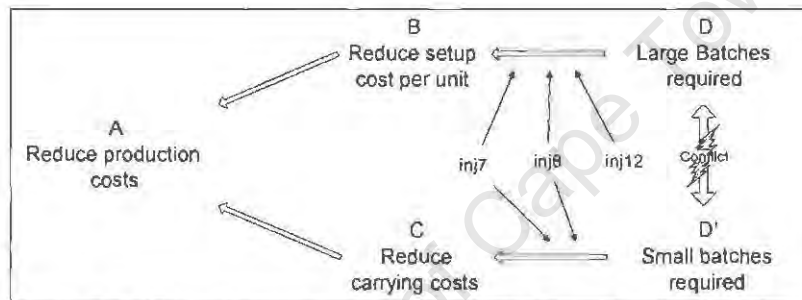
1. Carrying costs are part of the overall manufacturing costs.
5. The actions that are required for reducing carrying costs are different to those required for reducing idle time.
6. Idle time is only “bad” at bottleneck operations.

Injections:

Inj-10: Implement formally organised reorder system.

Inj-5: Form buying partnerships with other small manufacturing businesses or have long term contracts with single suppliers in order to command better services from suppliers.

Inj-11: Find alternate more reliable suppliers with shorter lead times.



Conflict Resolution Diagram 6-a: Resolving conflict concerning the optimum size of production batches.

Assumptions D' → C:

1. Smaller batches result in substantially shorter lead times. Therefore time between receiving payment for goods shipped and paying for the raw materials is reduced.
2. Smaller batches result in lower inventory in the manufacturing system. Therefore less money invested in inventory.

Assumptions D → B:

1. Large batches of work in the production process means that operations can run the same job for longer thereby reducing the number of changeovers.
2. Large batches of work stabilise manufacturing.

Assumptions B → A:

1. Changeover times are fixed.

2. Changeovers at any operation result in downtime, which lowers workcenter efficiency (reduces output). Therefore changeovers “cost” money.

Assumptions C → A:

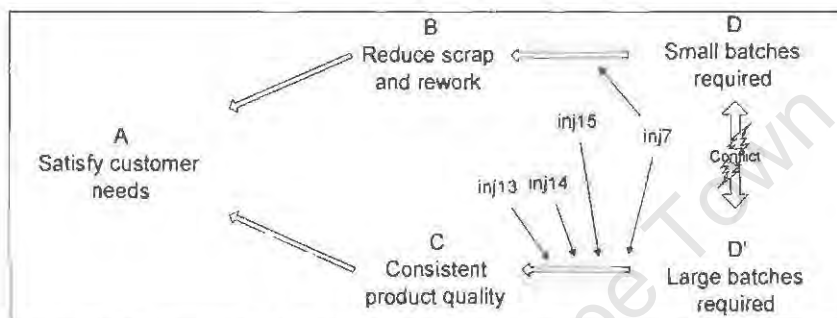
1. The cost of carrying inventory adds to manufacturing costs.

Injections:

Inj-7: Differentiate between transfer and process batches.

Inj-8: Implement a drum-buffer-rope pull-type production scheduling system.

Inj-12: Reduce changeover times.



Conflict Resolution Diagram 7-b: Resolving conflict concerning the optimum size of production batches.

Assumptions D' → C:

1. Equipment and tooling is inaccurate and difficult to set up resulting in quality inconsistency from one batch to another.
2. There are no alternative ways of ensuring quality consistency other than by having long runs of work for each setup.

Assumptions D → B:

1. Feedback about quality problems is slow if batch sizes are large.
2. Quality inspections are not always performed as instructed.

Assumptions B → A:

1. Scrap and rework cause delays in production and additional unplanned manufacturing costs.
2. Customers will only purchase parts that are delivered when promised and that are competitively priced.

3. The actions that are required for reducing manufacturing costs through reduced scrap and rework are different to those required for ensuring quality consistency.

Assumptions C → A:

1. Customers will only purchase goods that are to their desired specifications, i.e. “fit for use”.
2. The actions that are required for ensuring quality consistency are different to those required for reducing manufacturing costs through reduced scrap and rework.

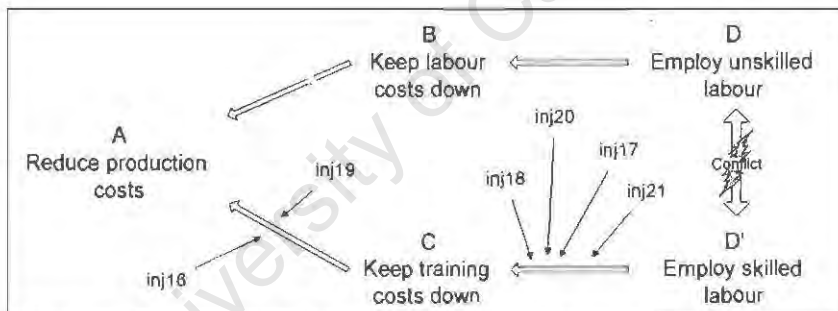
Injections:

Inj-13: Develop and make fixtures and tooling that can be easily and quickly set up accurately.

Inj-14: Educate workers on the importance of quality and get their commitment to it.

Inj-15: Develop and make useable quality inspection tools that are part of the manufacturing system.

Inj-7: Differentiate between process and transfer batch sizes. Feedback is easier and quicker if transfer batches are smaller than process batches.



Conflict Resolution Diagram 8: Resolving conflict between employing skilled or unskilled labour.

Assumptions D' → C:

1. Skilled labour has sufficient training and experience to perform the necessary manufacturing tasks without further training.
2. Training workers results in reduced production time and therefore “costs” money.
3. There are many hidden “costs” associated with employing unskilled workers.

Assumptions D → B:

1. Unskilled labour “costs” less than skilled labour.
2. Limited financial resources means that cost of labour must be kept to a minimum.

Assumptions B → A:

1. Reducing the cost of labour will reduce production costs.
2. The manufacturing process comprises mostly simple tasks requiring unskilled labour.

Assumptions C → A:

1. There is not enough time available to train the workers internally, therefore the business will have to outsource training of unskilled workers.
2. Limited resources mean that training cannot be outsourced.

Injects:

Inj-16: Use planned idle-time to train and educate workers.

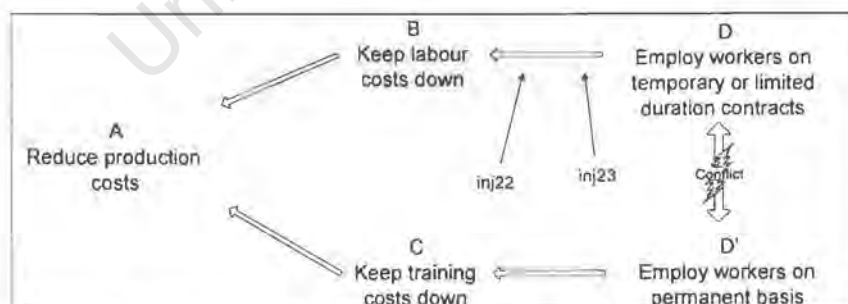
Inj-17: Post training charts that display the level of skill and experience each worker has as well as targets that each worker should strive for.

Inj-18: Encourage workers to want to learn by filling vacant or new positions from within the business.

Inj-19: Use training facilities offered by equipment suppliers to do on-the-job training.

Inj-20: Redesign the manufacturing process to make tasks easier to perform. Simple tasks require less skill and quicker training.

Inj-21: Feedback about work improvements must be made immediately to improve the effectiveness of the learning process.



Conflict Resolution Diagram 9: Resolving conflict between employing workers on a temporary or permanent basis.

Assumptions D' → C:

1. Workers employed on a permanent basis will be motivated to learn resulting in reduced and more effective training.
2. Employing workers on a temporary basis as opposed to permanent basis results in high staff turnover, which means there are constantly new workers in the manufacturing system requiring constant training.
3. Employing workers on a permanent basis means that once they have been trained to perform certain tasks no further training is required.
4. Productivity of workers that have no job security is very low.

Assumptions D → B:

1. Customer demands vary considerably and unpredictably resulting in fluctuating manufacturing requirements.
2. Employing permanent staff means that when manufacturing demand is low workers will have nothing to do and will therefore “cost” money.

Assumptions B → A:

3. Reducing the cost of labour will reduce manufacturing costs.
4. Limited working capital means that labour costs must be kept to a minimum.

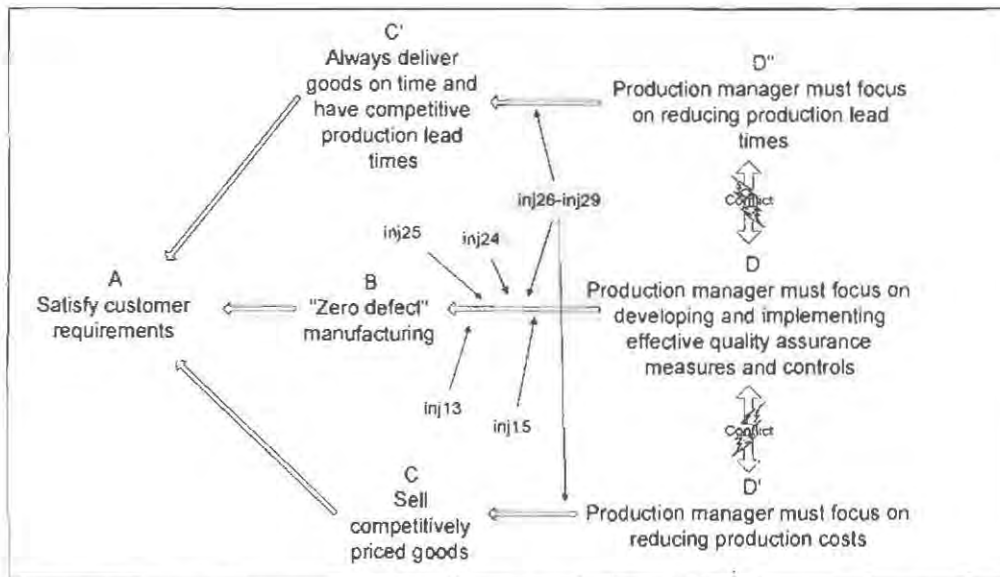
Assumptions C → A:

1. There is no time to train workers internally and outsourcing training “costs” money.
2. Limited working capital means that training costs must be kept to a minimum.
3. Training workers internally will result in manufacturing downtime, which “costs” money.

Injectors:

Inj-22: Have long-term contracts with customers to balance the output of the plant.

Inj-23: Research and develop new products that can be made when capacity is greater than customer demand. Ensure that there is a need for these new products before devoting time and resources to the development thereof.



Conflict Resolution Diagram 10: Resolving conflict concerning how production managers should spend their time.

Assumptions $D'' \rightarrow C'$:

1. Focusing on developing and implementing effective quality assurance measures and controls or on reducing production costs prevents the production manager from spending time focusing on reducing manufacturing lead-times.
2. The production manager is the only person in the business who can find ways of shortening manufacturing lead-times.

Assumptions $D \rightarrow B$:

1. Focusing on reducing production lead-times or on reducing manufacturing costs prevents the production manager from spending time focusing on developing and implementing effective quality assurance measures and controls.
3. The production manager is the only person in the business who can develop and implement effective quality assurance measures and controls.

Assumptions $D' \rightarrow C$:

1. Focusing on developing and implementing effective quality assurance measures and controls or on reducing manufacturing lead times prevents the production manager from spending time focusing on reducing manufacturing costs.
2. The production manager is the only person in the business who can find ways of reducing manufacturing costs.

Assumptions $D' \leftrightarrow D \leftrightarrow D''$:

1. Production managers do not have enough time to do all three.

Assumptions $B \rightarrow A$:

1. Achieving “zero defect” manufacturing is more important than having competitive manufacturing lead-times or competitively priced goods.
2. Shortening lead-times and ensuring that promised lead-times are met will result in drop in the quality standard of goods produced, in increased defects and in increased production costs.
3. Actions that are required for achieving “zero defect” manufacturing are different to those required for reducing lead-times and for meeting promised delivery dates and for reducing manufacturing costs.
4. Competitors offer better quality products.
5. Customers purchase from suppliers offering the best product quality.

Assumptions $C' \rightarrow A$:

1. Actions required for reducing lead-times and for ensuring that goods are never delivered late are not the same as those required for achieving “zero defect” manufacturing or for reducing manufacturing costs.
2. Ensuring that lead-times are competitive and that promised lead-times are met is more important than supplying top-quality goods and supplying competitively priced goods.
3. Competitors offer shorter lead times.
4. Customers purchase from suppliers with the shortest lead-time.

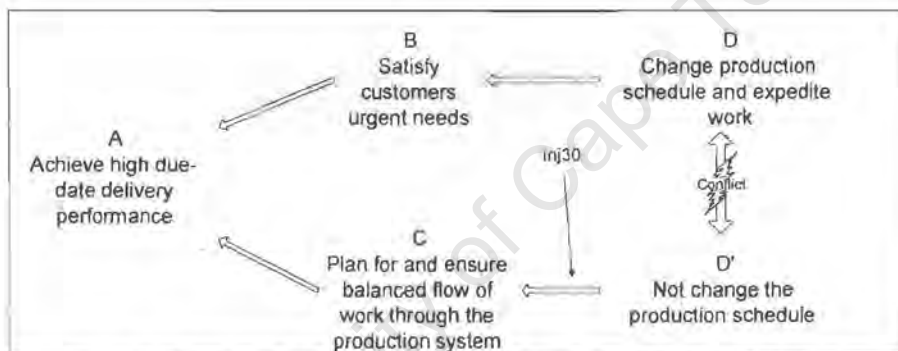
Assumptions $C \rightarrow A$:

1. Actions required for reducing manufacturing costs not the same as those required for achieving “zero defect” manufacturing or for reducing manufacturing lead times or for ensuring that deliveries are made on time.
2. Competitors supply similar products but at lower prices.
3. Customers purchase the cheapest goods available in the market.

Injectors:

Inj-24: Educate and train workers to inspect work themselves.

- Inj-25: Have clearly defined and understandable objective quality standards for every step in the manufacturing process.
- Inj-13: Develop and make fixtures and tooling that can be easily and quickly set up accurately,
- Inj-15: Develop and make useable quality inspection tools that are part of the manufacturing system.
- Inj-26: Institute a suggestion system where workers can make suggestions for improving the performance of the system.
- Inj-27: Educate and train workers about the need for constant manufacturing system performance improvement and about how to achieve it.
- Inj-28: Post improvement progress charts with targets and achievements gained.
- Inj-29: Reward workers for their successful performance improvement efforts.



Conflict Resolution Diagram 11: Resolving conflict between making changes to the production schedule or leaving the production schedule as planned.

Assumptions $D' \rightarrow C$:

1. Changing the production schedule will disturb the balanced flow of work through the production system.
2. The production schedule allows for only limited flexibility to fit in urgent orders.
3. Changing the production schedule will result in additional changes required later.
4. Additional changes cause unplanned excessive delays.

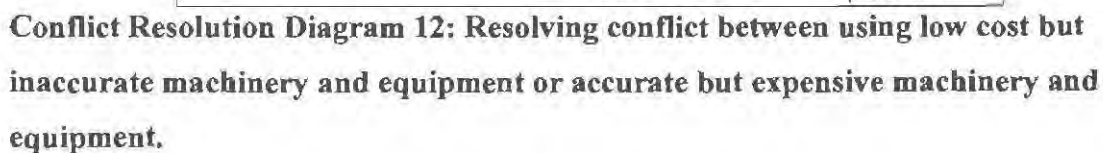
Assumptions $D \rightarrow B$:

1. Urgent orders cannot be met without changing the production schedule.
2. Urgent orders are important and must therefore be delivered on time.

1. Urgent orders are more important than planned production.
2. There are no alternative ways to meet urgent orders other than by rescheduling or re-planning production.
3. The actions that are required for satisfying urgent customer needs are different to those required for required for balancing the flow of work through the manufacturing system.

1. If production goes as planned due-date performance will be high.
2. Insufficient time has been scheduled for the inclusion of urgent orders.
3. The actions that are required for balancing the flow of work through the manufacturing system are different to those required for satisfying urgent customer needs.

Inj-30: Make the production system more flexible and more responsive to changes by reducing inventory, reducing changeover times, reducing batch sizes, reducing waste and by coupling operations.



Assumptions D' → C:

1. The use of inaccurate machinery and equipment results in a high level of substandard work that requires correction or scrapping.
2. There is no alternative ways of reducing scrap and rework other than by using accurate equipment.

Assumptions D → B:

1. "Cost" savings achievable through reduced scrap and rework will not justify using more expensive and accurate equipment in manufacturing.
2. Reducing the investment per unit produced requires using low cost equipment.
3. Workers use equipment negligently resulting in frequent breakdowns, regardless of the quality or capability of the equipment.

Assumptions D' ↔ D:

1. Accurate machinery and equipment costs more than inaccurate or inconsistent machinery and equipment.
2. The business has limited working capital and limited financial resources and therefore cannot purchase expensive machinery and equipment.

Assumptions B → A:

1. Reducing the investment in the manufacturing system brings down the manufacturing costs.
2. Management cannot be sure that using expensive equipment will result in reduced scrap and rework and subsequently reduced manufacturing costs.

Assumptions C → A:

1. Reducing scrap and rework will bring manufacturing costs down.
2. Reducing scrap and rework has other benefits in the manufacturing system besides reducing manufacturing costs.

Injectors:

Inj-13: Develop and make fixtures and tooling that can be easily and quickly set up accurately.

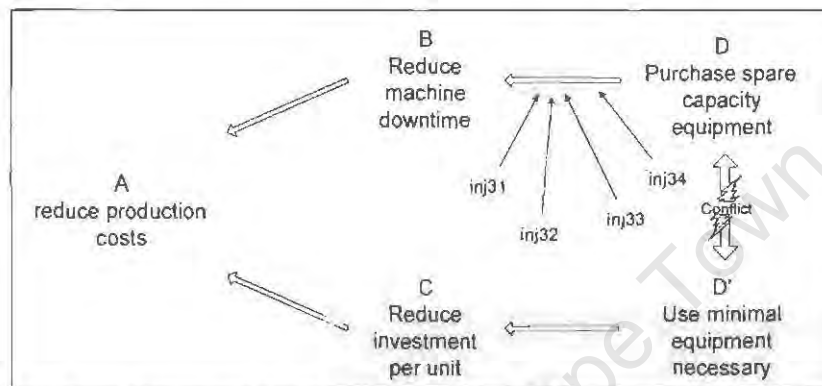
Inj-7: Differentiate between process and transfer batch sizes. Feedback is easier and quicker if transfer batches are smaller than process batches.

Inj-31: Develop and make preventative fixtures and tooling that prevents equipment from being abused. For example, cut-off switches, movement stops, etc.

Inj-32: Educate and train workers to perform preventative maintenance tasks on the equipment they use, such as oil changes, keeping machinery and equipment clean and workbenches uncluttered and checking and tightening any loose fasteners.

Inj-33: Reward workers for looking after their equipment.

Inj-34: Train the workers how to operate the machinery and equipment correctly.



Conflict Resolution Diagram 13: Resolving conflict between having minimal machinery and equipment necessary or having spare capacity machinery and equipment

Assumptions $D' \rightarrow C$:

1. “Cost” savings achievable through reducing downtime will not justify purchasing spare capacity equipment.
2. Spare capacity equipment is infrequently used resulting in very low utilisation.
3. Idle time “costs” money so equipment must be kept busy all the time, i.e. there must be high equipment utilisation.

Assumptions $D \rightarrow B$:

1. Machinery and equipment only needs to be repaired when it breaks down.
2. Machinery and equipment is unreliable and breaks down frequently.
3. Machinery and equipment breakdowns cause delays in production.
4. There is no alternative way of reducing delays caused by breakdowns other than by increasing the capacity of the manufacturing process.

Assumptions B → A:

1. Idle time “costs” money.
2. Reducing idle manufacturing time reduces manufacturing costs.

Assumptions C → A:

1. Small profit margins result in the need to minimise investment per unit manufactured in the manufacturing system.
2. Reducing investment per unit reduces manufacturing costs.
3. Management cannot be sure that newly purchased machinery and equipment will not breakdown while other machinery and equipment is down.

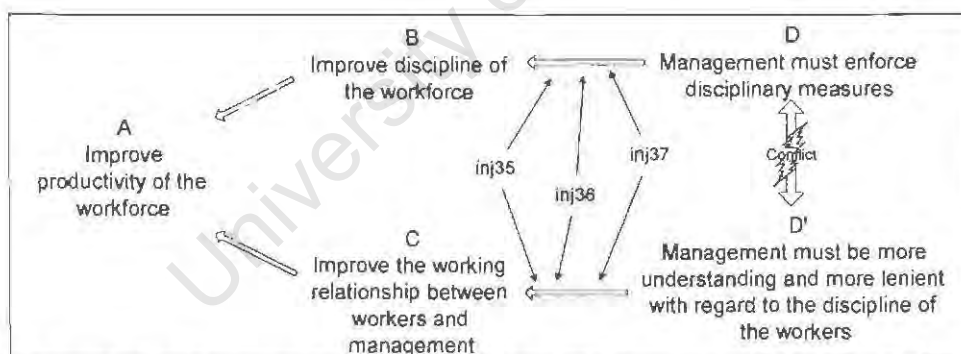
Injections:

Inj-31: Develop and make preventative fixtures and tooling that prevents equipment from being abused. For example, cut-off switches, movement stops, etc.

Inj-32: Educate and train workers to perform preventative maintenance tasks on the equipment they use, such as oil changes, keeping machinery and equipment clean and workbenches uncluttered and checking and tightening any loose fasteners.

Inj-33: Reward workers for looking after their equipment.

Inj-34: Train the workers how to operate the machinery and equipment correctly.



Conflict Resolution Diagram 14: Resolving conflict between enforcing disciplinary measures and being more lenient and understanding with regard to the discipline of workers.

Assumptions D' → C:

1. Enforcing disciplinary action on ill-disciplined workers results in a confrontational relationship between the employer and the employee.

2. The discipline of workers is affected by outside influences and events that management cannot control.
3. There is no alternative way of ensuring a productive working relationship between employee and employer other than by management being understanding and lenient with regard to the discipline of the workers.

Assumptions D → B:

1. If no disciplinary action is taken against ill-disciplined workers their discipline will deteriorate.
2. There is no other way of improving the discipline of the workers than by taking disciplinary action against ill-disciplined workers.

Assumptions B → A:

1. Management and workers work very closely in small businesses.
2. A healthy working relationship between management and workers is an essential element for keeping the workforce motivated and productive.
3. Improving the relationship between management and workers will in the long-term result in a disciplined workforce.

Assumptions C → A:

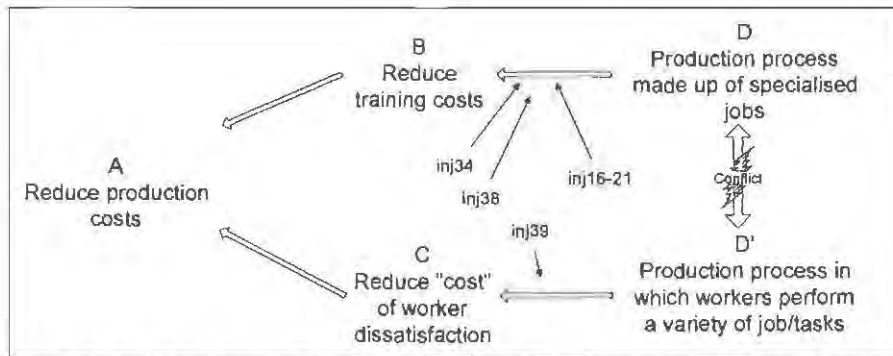
1. In order to improve the productivity of the workforce the discipline of the workforce must improve.
2. The actions required by management to improve the discipline of the workers are not the same as those required for improving the working relationship between management and workers.

Injectons:

Inj-35: Educate the workers about the need for good discipline and the effects of ill discipline.

Inj-36: Improve the moral of the workers, their motivation and their commitment to their work.

Inj-37: Educate and train workers on ways to improve their productivity. Use directive questions to point them in the right direction on making improvements.



Conflict Resolution Diagram 15: Resolving conflict between a manufacturing process made up of specialised jobs and a manufacturing process in which workers perform a variety of tasks.

Assumptions $D' \rightarrow C$:

1. Specialisation of jobs leads to worker dissatisfaction.
2. Benefits gained through enlarging workers' jobs outweighs the cost reduction gained by having only specialised jobs in the manufacturing system.
3. Workers have the opportunity to show initiative and to improve themselves.
4. Specialisation causes fatigue and boredom.

Assumptions $D \rightarrow B$:

1. Specialisation of jobs means that training can be performed easily whereas a multi-skilled workforce requires constant training.
2. Simple and repetitive tasks result in high workcenter efficiencies.

Assumptions $B \rightarrow A$:

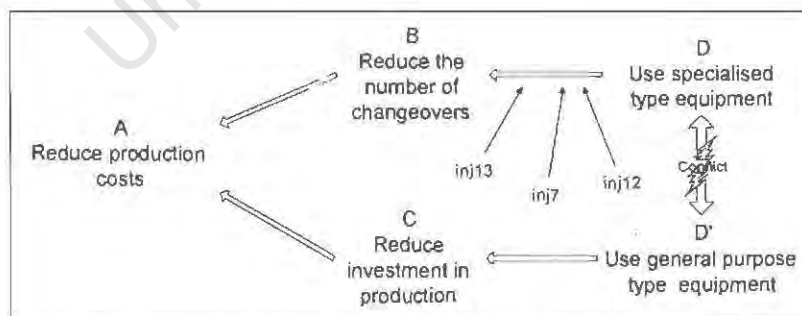
1. Training costs are part of overall manufacturing costs.
2. Training the workforce to perform multiple tasks is only beneficial in the long term.
3. Worker turnover is high resulting in wasted training every time workers leave.

Assumptions $C \rightarrow A$:

1. Reducing manufacturing costs by enlarging jobs in the manufacturing process outweighs the benefits derived through reduced training.
2. Worker dissatisfaction causes high absenteeism, high staff turnover, tardiness, intentional disruptions of the production process, intentional abuse of machinery, equipment and tools, disregard for instructions and intentional production of substandard work, which all negatively affect manufacturing costs.

Injections:

- Inj-38: Rotate workers from one task to another periodically to prevent boredom.
- Inj-16: Use planned idle-time to train and educate workers.
- Inj-17: Post training charts that display the level of skill and experience each worker has as well as targets that each worker should strive for.
- Inj-18: Encourage workers to want to learn by filling vacant or new positions from within the business.
- Inj-19: Use training facilities offered by equipment suppliers to do on-the-job training.
- Inj-20: Redesign the manufacturing process to make tasks easier to perform. Simple tasks require less skill and quicker training.
- Inj-21: Feedback about work improvements must be made immediately to improve the effectiveness of the learning process.
- Inj-39: There are limited variety of tasks and opportunities in small manufacturing businesses. The following methods can be used to keep workers motivated, moral high and interest in their work high.
- Have regular motivational speakers for the workers.
 - Always treat workers with respect.
 - Encourage workers to constantly think of ways to improve their work.
 - Treat the workers like human beings not human machines.
 - Never put workers into situations where their dignity is compromised.
 - Make workers feel secure and confident in their jobs.



Conflict Resolution Diagram 16: Resolving conflict between using specialised or general type machinery and equipment in the manufacturing system

Assumptions D' → C:

1. General-purpose machinery and equipment can be used for a wider variety of operations and tasks than specialised type machinery and equipment. Therefore less machinery and equipment is required.
2. The use of specialised machinery and equipment limits the flexibility of the manufacturing system.
3. The bottleneck operation is the only operation that should be running at maximum output. Frequent changeovers at non-bottlenecks do not affect the overall output unless they become the bottleneck.

Assumptions D → B:

1. General-purpose machinery and equipment require lengthy changeovers from job to job.
2. Batches are small requiring frequent changeovers.
3. Changeovers result in manufacturing idle time, which lowers workcenter efficiencies and utilisation and therefore “costs” money.
4. Specialised machinery and equipment does not require lengthy changeovers.
5. General-purpose machinery and equipment require additional jigs, patterns and adaptation to be used effectively, which “cost” money.

Assumptions B → A:

1. Changeovers result in wasted production time and wasted manufacturing time “costs” money.

Assumptions C → A:

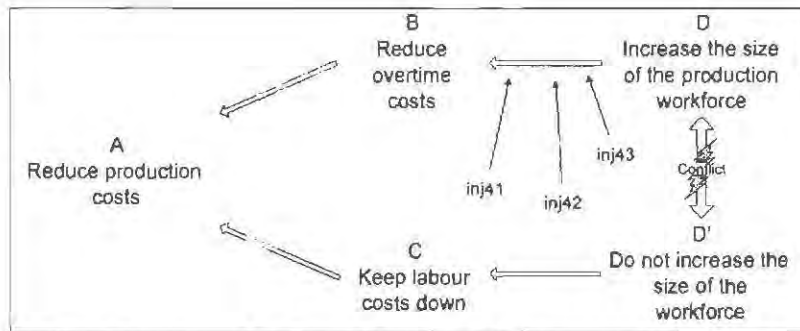
1. Small profit margins result in the need to minimise investment per unit produced in the manufacturing system.

Injectors:

Inj-7: Differentiate between process and transfer batches.

Inj-12: Reduce changeover times.

Inj-13: Develop and make fixtures and tooling that can be easily and quickly set up accurately.



Conflict Resolution Diagram 17: Resolving conflict concerning the size of the production workforce

Assumptions D' → C:

1. Manufacturing is labour intensive.
2. Overtime would not be required if productivity of the workers were higher.
3. Production actuality is less than capability and potentiality of the manufacturing system, particularly when labour is concerned.
4. Increasing the size of the workforce will result in idle time when capacity is greater than demand, and idle-time "costs" money.
5. Additional machinery and equipment must be purchased for additional workers to use resulting in additional capital investment in the business.
6. Once workers are employed it is difficult to retrench or dismiss them.

Assumptions D → B:

1. Production is labour intensive.
2. If the size of the workforce is increased the capacity of the manufacturing system increases.
3. If capacity is increased overtime will not be required.
4. Time lost to absenteeism and tardiness is excessive and causes delays in production.
5. Production actuality is less than market demand but market demand is less than production capability and potentiality.
6. Overtime "costs" more than regular time worked.

Assumptions B → A:

1. Having to work overtime increases manufacturing costs.

2. There are no alternative ways of reducing overtime other than by increasing the size of the workforce thereby increasing labour costs.

Assumptions C → A:

1. Labour costs are a major part of the overall manufacturing costs.
2. The actions needed to minimise labour costs are not the same as those for reducing overtime costs.

Injections:

Inj-41: Improve the workers morale and motivation and their interest in and commitment to their work.

Inj-42: Improve the effectiveness of production planning.

Inj-43: Concentrate efforts on maximise the output of the bottleneck.

9.2 Injections:

The effects of the injections proposed in the previous section are shown in the future reality tree in the following section. These injections were either new actions or conditions that did not exist in current reality and therefore had to be put into existence in order to achieve the desired future reality.

It must be noted that these injections are not solutions – they are ideas for solutions. The difference between an idea and a solution is that solutions have been tested and their implementation rigorously planned. Solutions are provided in section 10.1 Achieving Improved Manufacturing Performance.

10 SMALL BUSINESS MANUFACTURING SYSTEM FUTURE REALITY

TREE:

Dettmer [54] stated that the future reality tree was designed to answer the second part of the question “what to change to?” by validating a new system configuration. The future reality tree used the same causality relationship structure that was used in the current reality tree, but instead of working from the top (from an undesirable effect) downwards (identifying its root cause), the process worked from the bottom (from proposed injections) upwards (verifying its desirable effects).

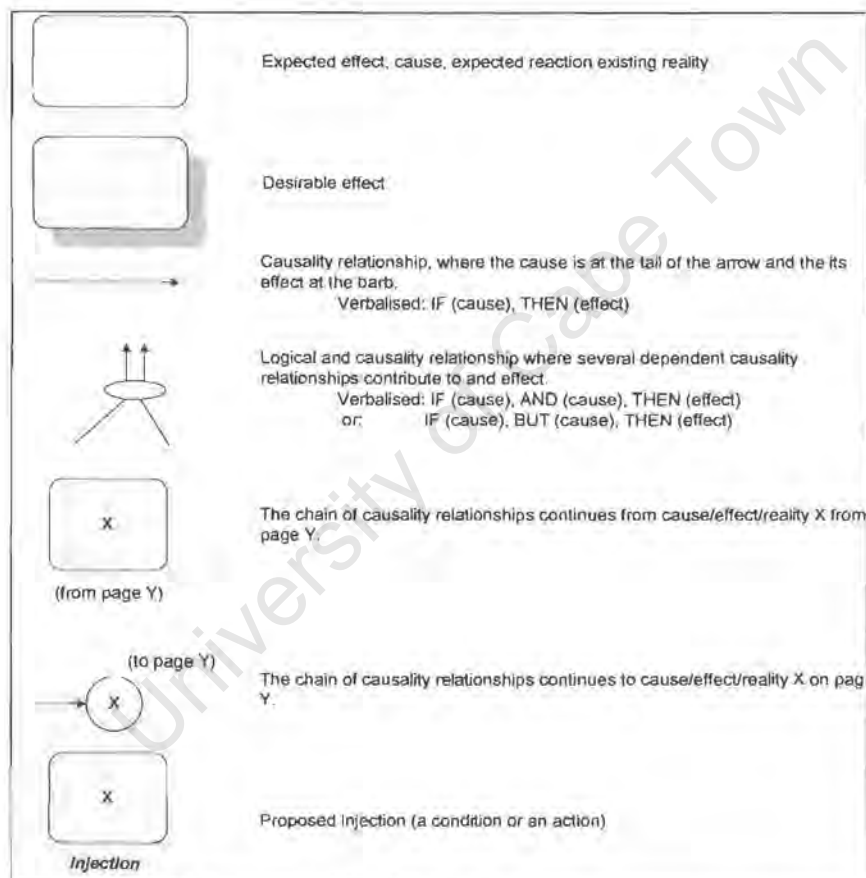


Figure 57: Future Reality Tree (FRT) Symbology

The following 19 pages contain The Future Reality Tree that was built for checking the effects of the proposed injections.

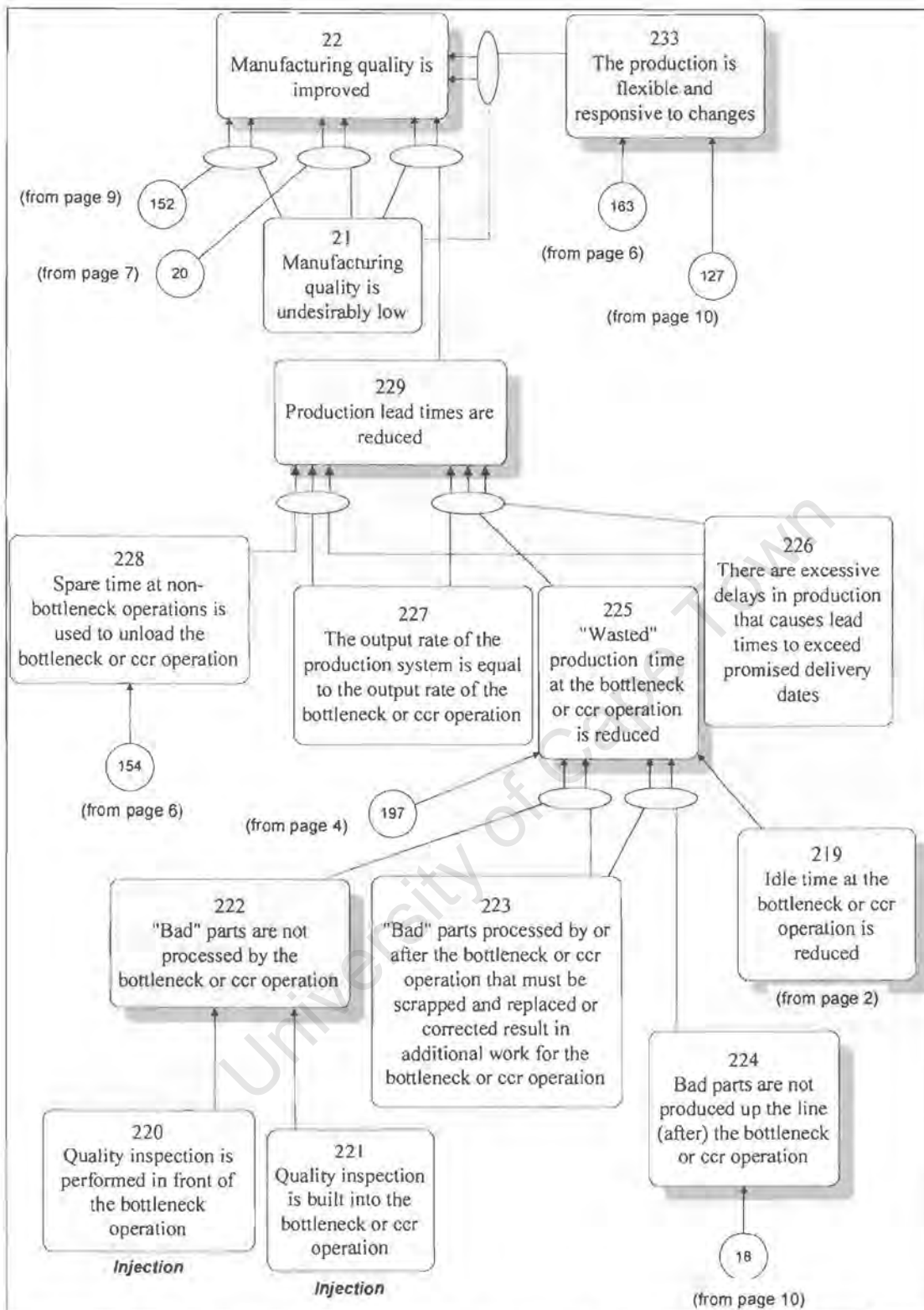


Figure 58-Page 1: Small Manufacturing Business Future Reality Tree:

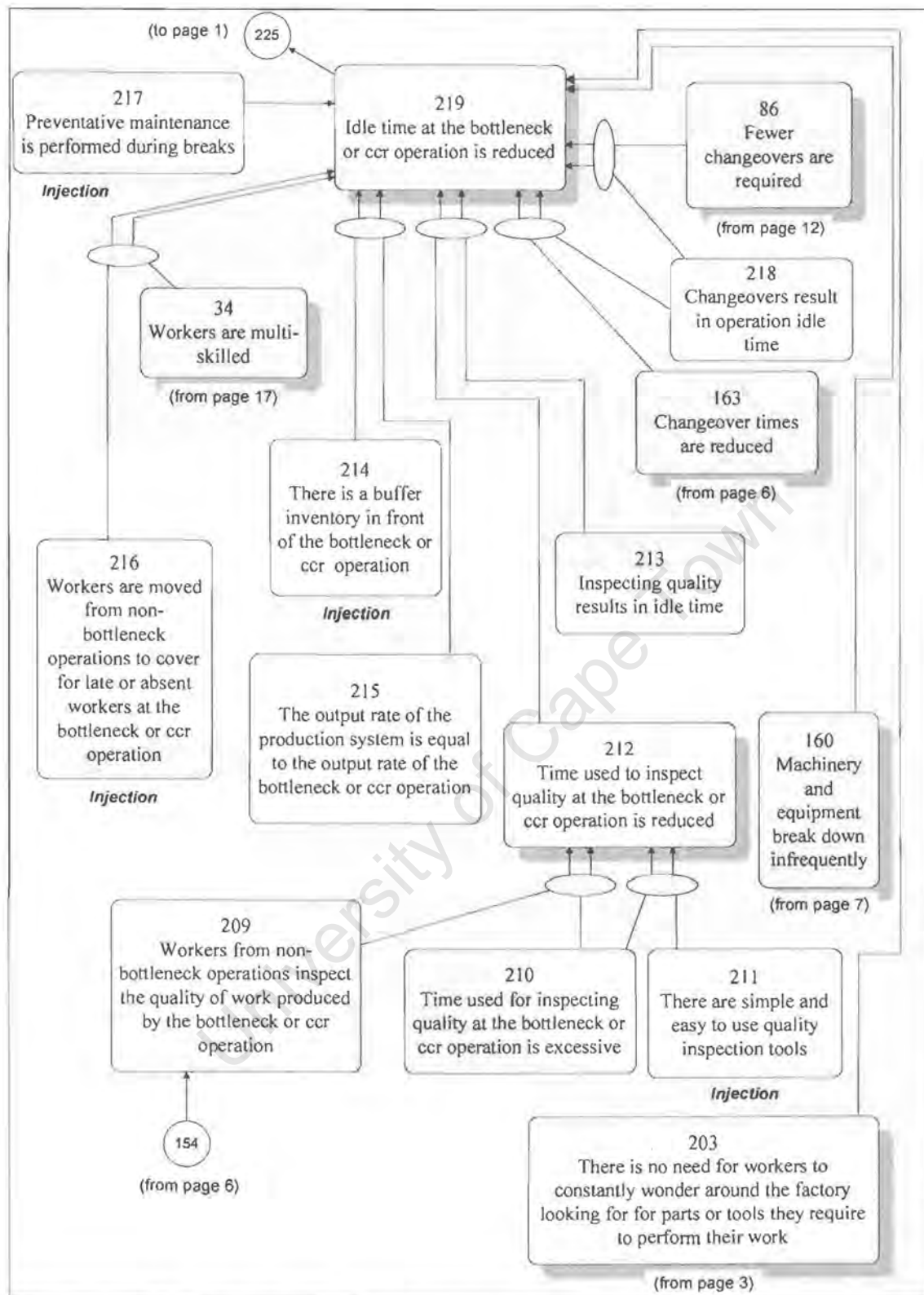


Figure 58-Page 2: Small Manufacturing Business Future Reality Tree:

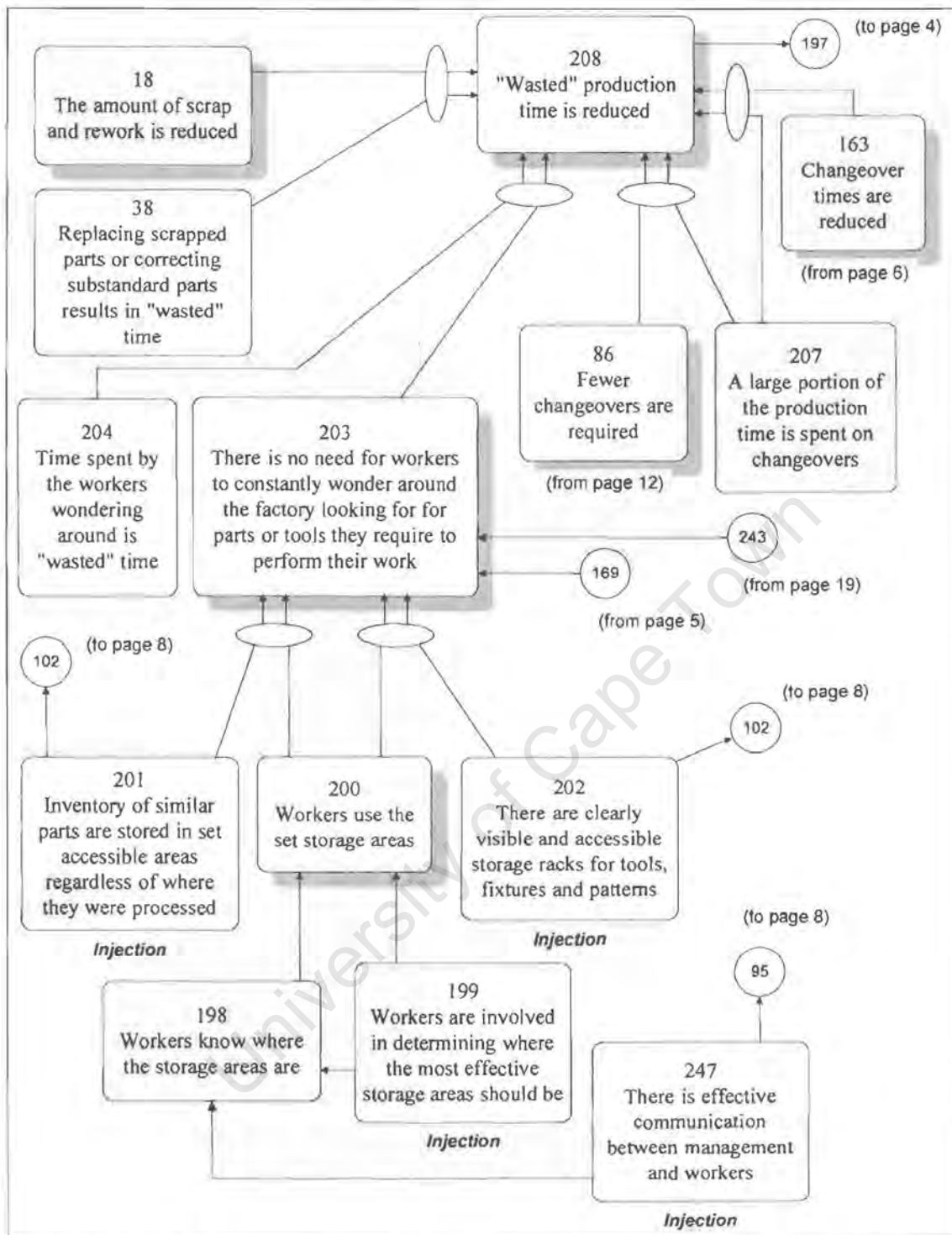


Figure 58-Page 3: Small Manufacturing Business Future Reality Tree:

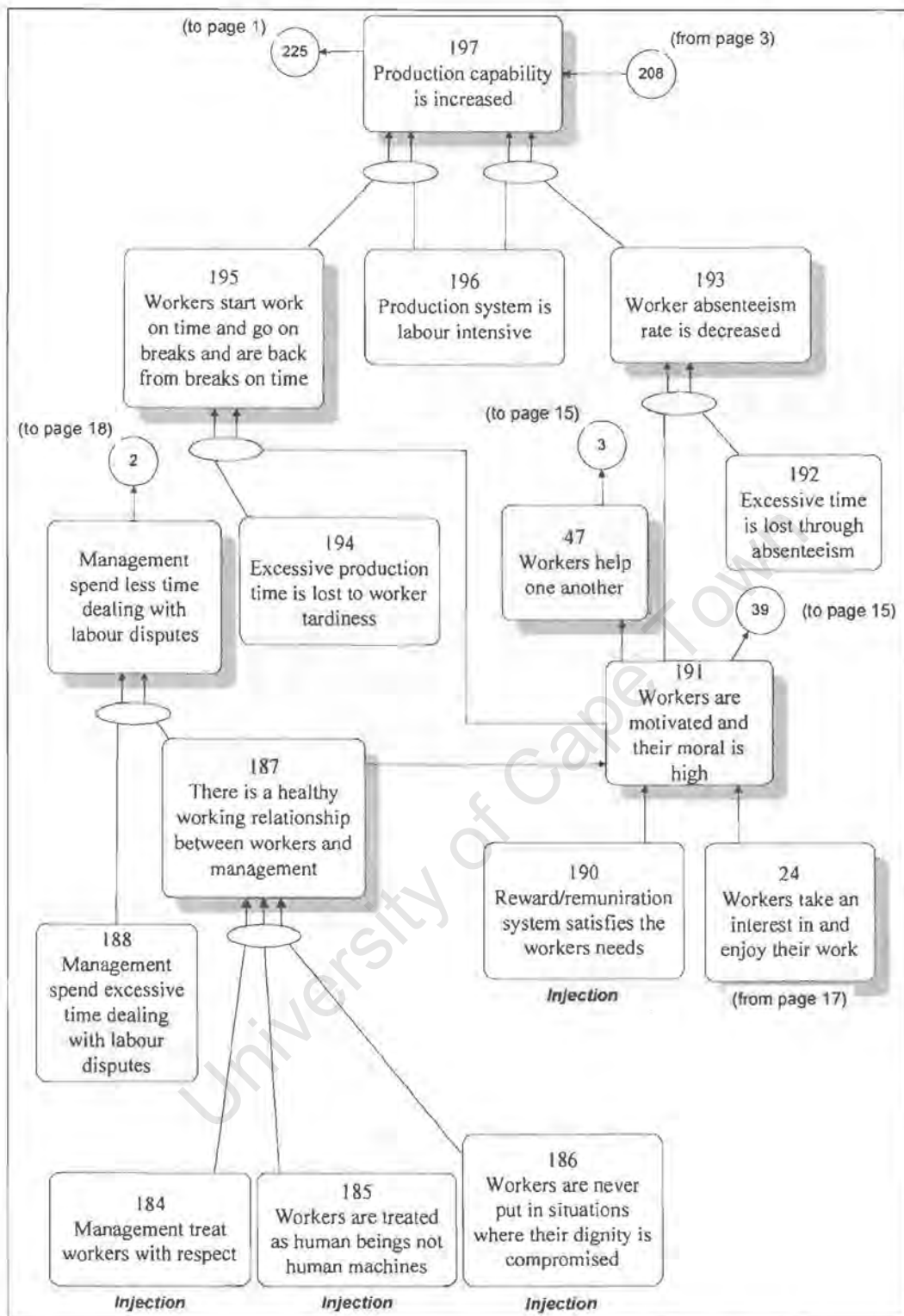


Figure 58-Page 4: Small Manufacturing Business Future Reality Tree:

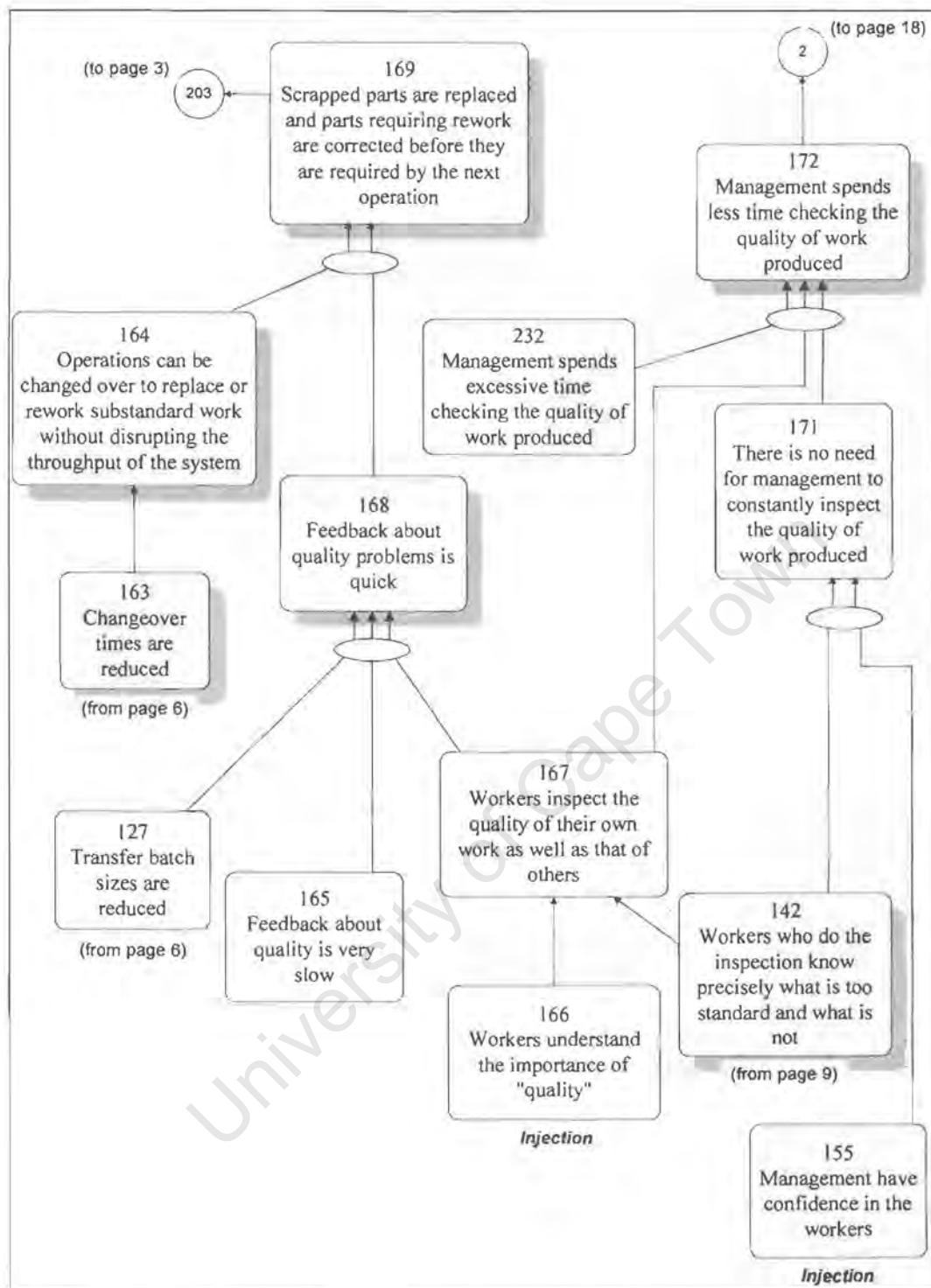


Figure 58-Page 5: Small Manufacturing Business Future Reality Tree:

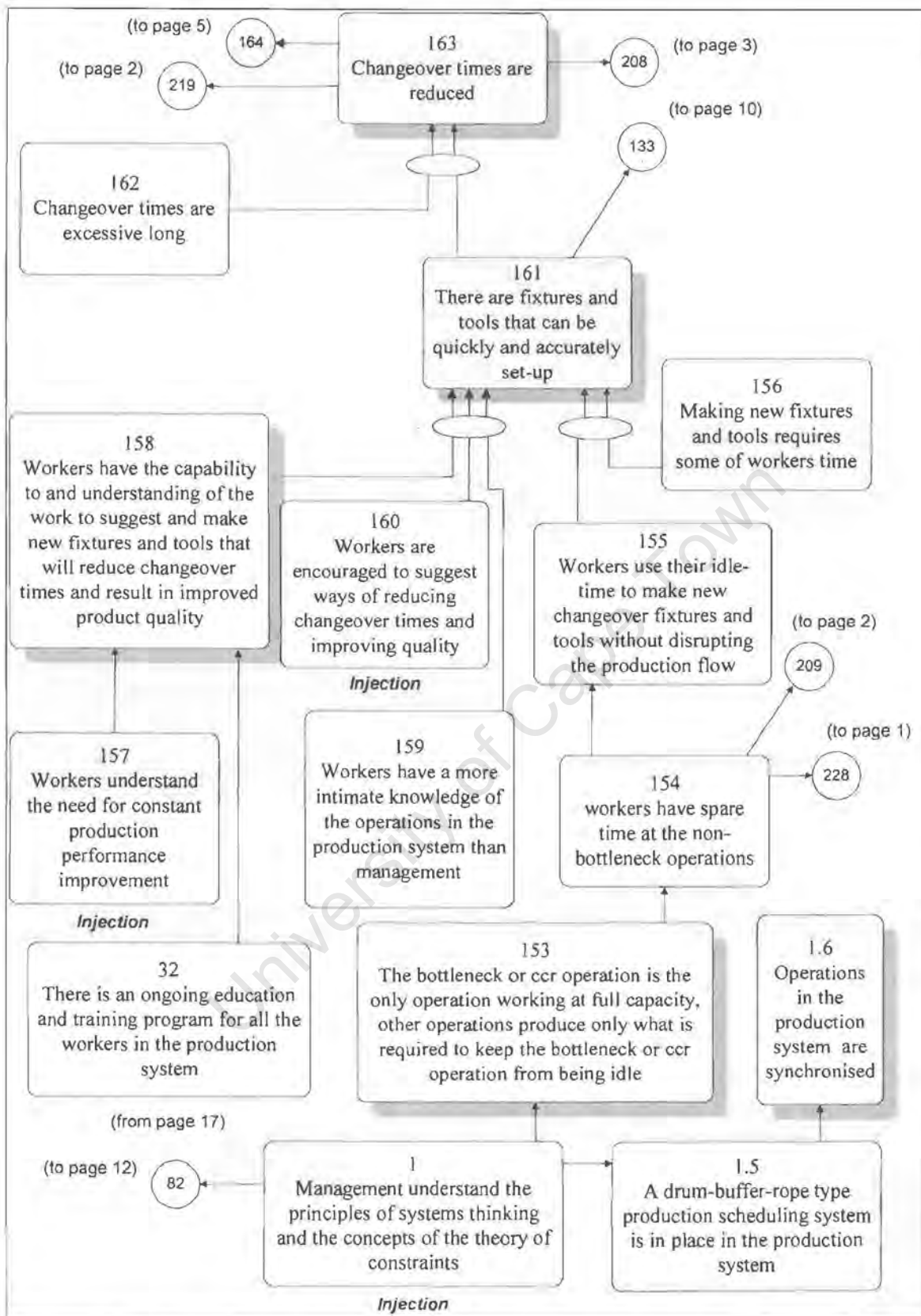


Figure 58-Page 6: Small Manufacturing Business Future Reality Tree:

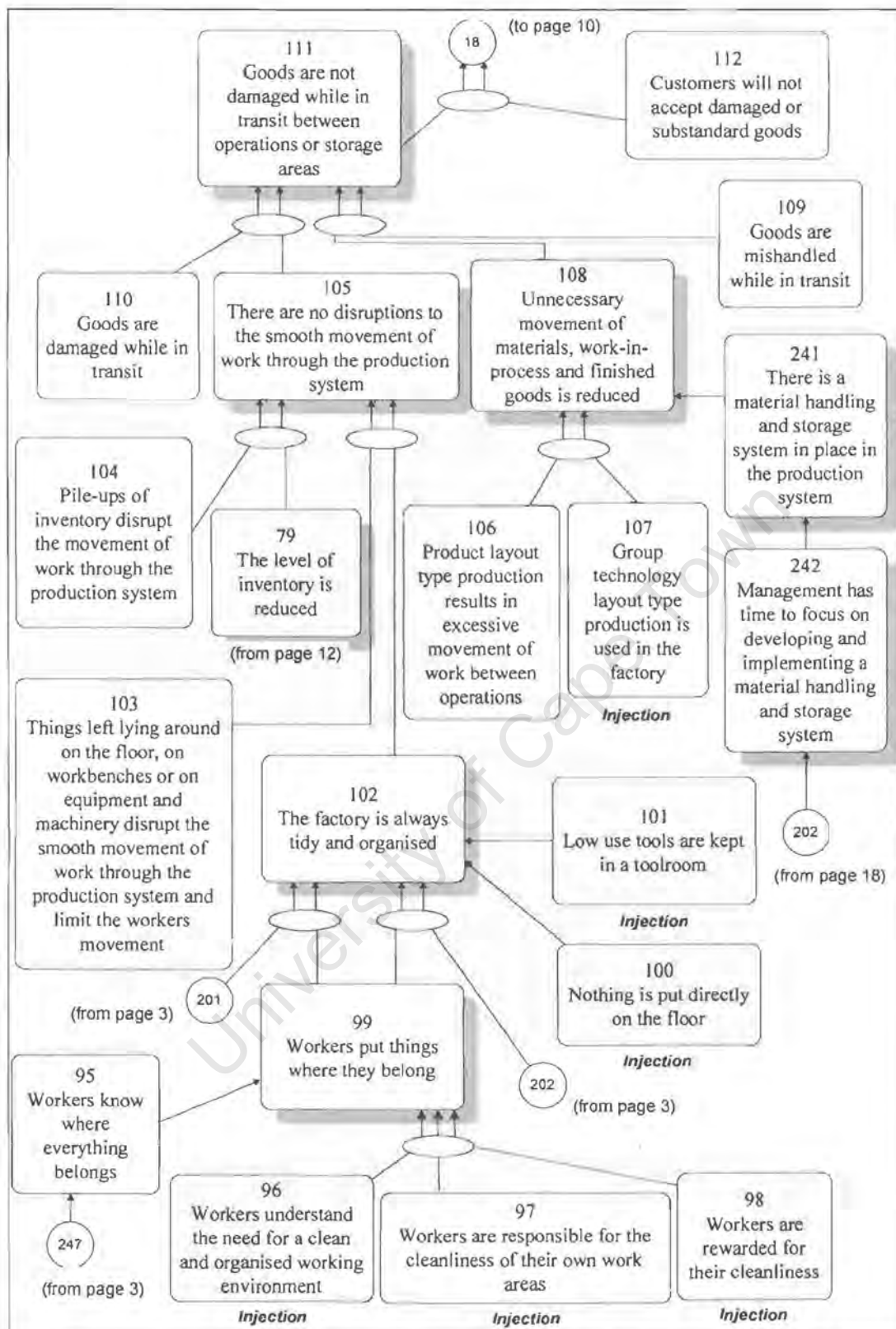


Figure 58-Page 8: Small Manufacturing Business Future Reality Tree:

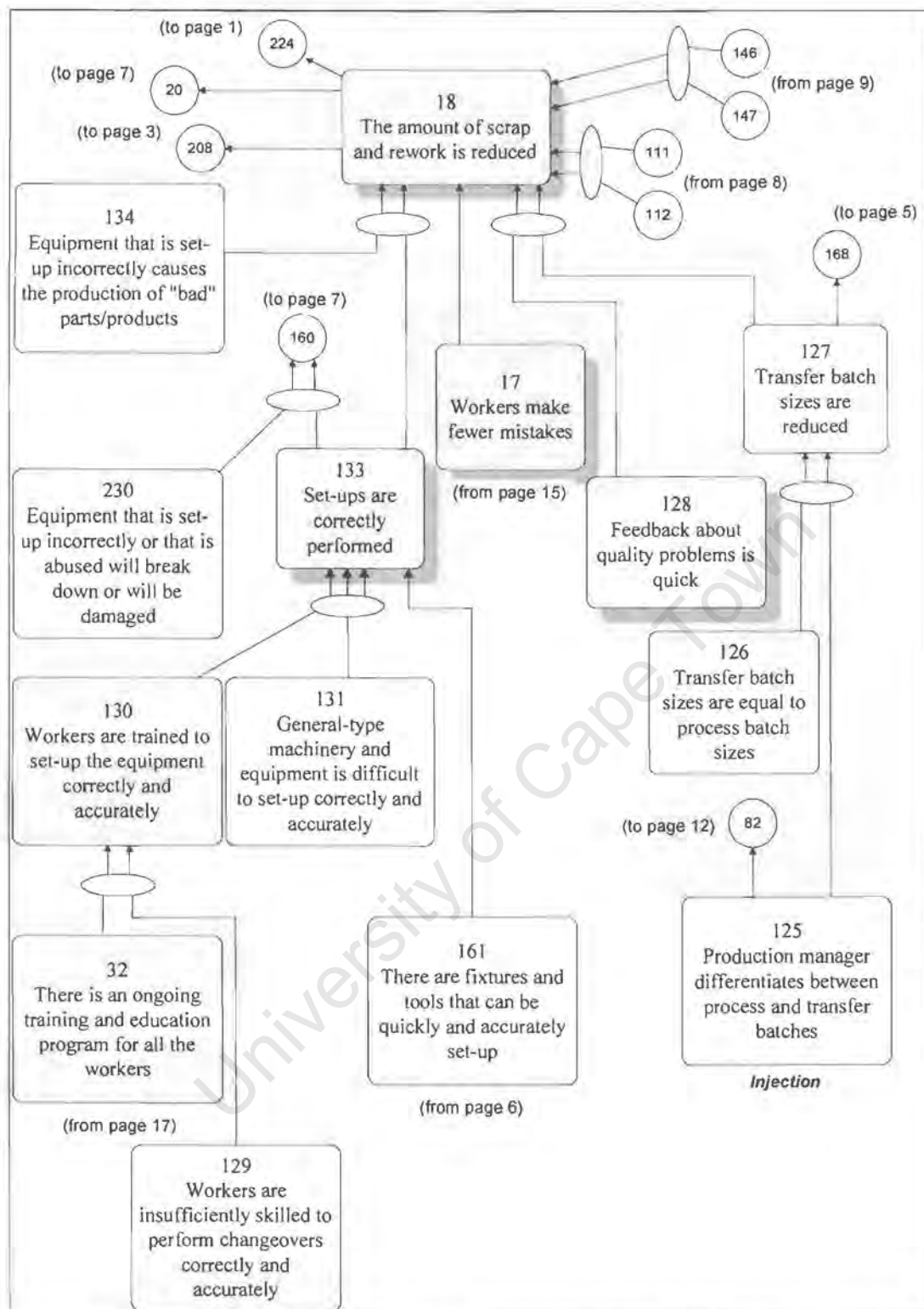
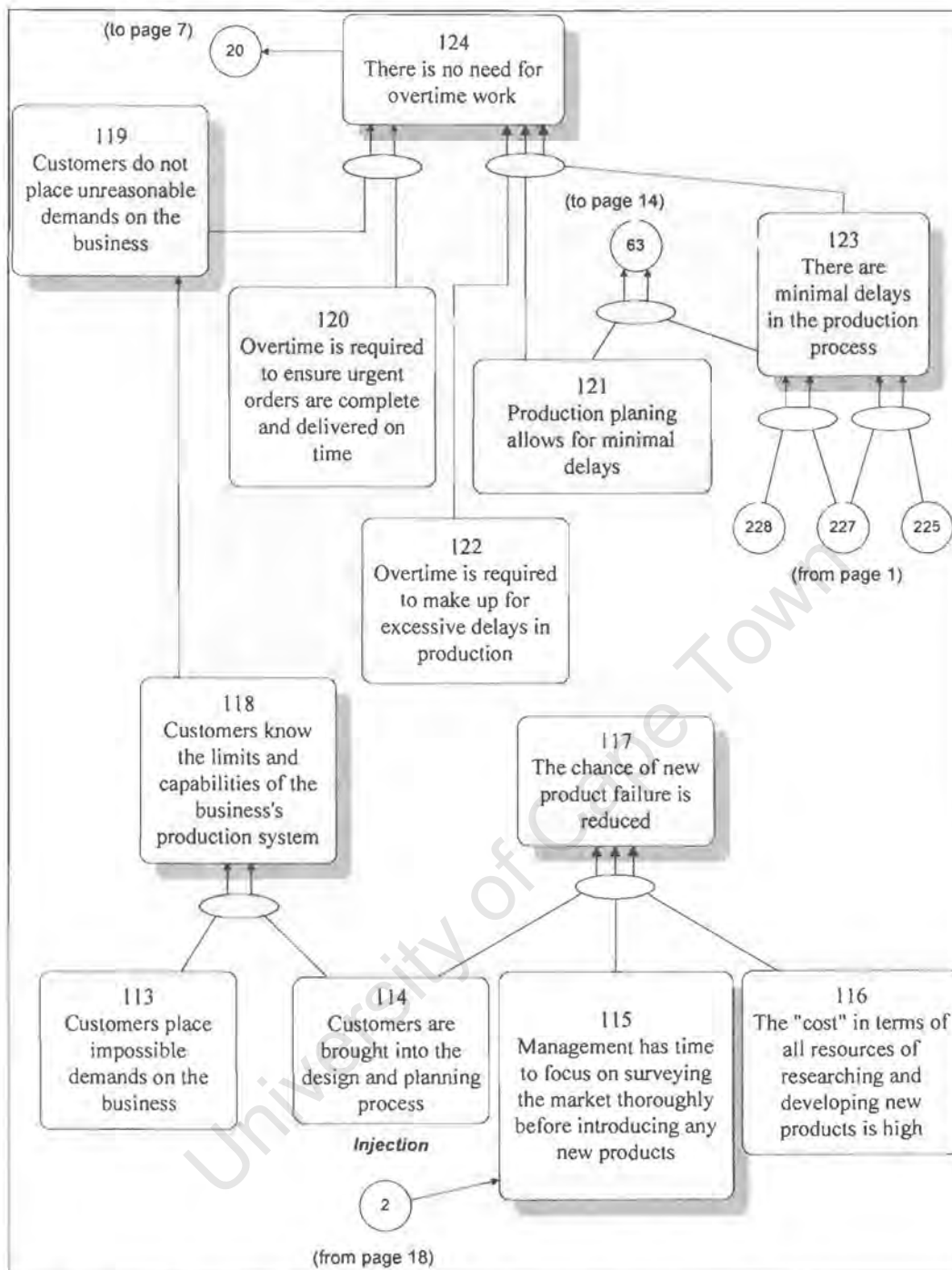


Figure 58-Page 10: Small Manufacturing Business Future Reality Tree:



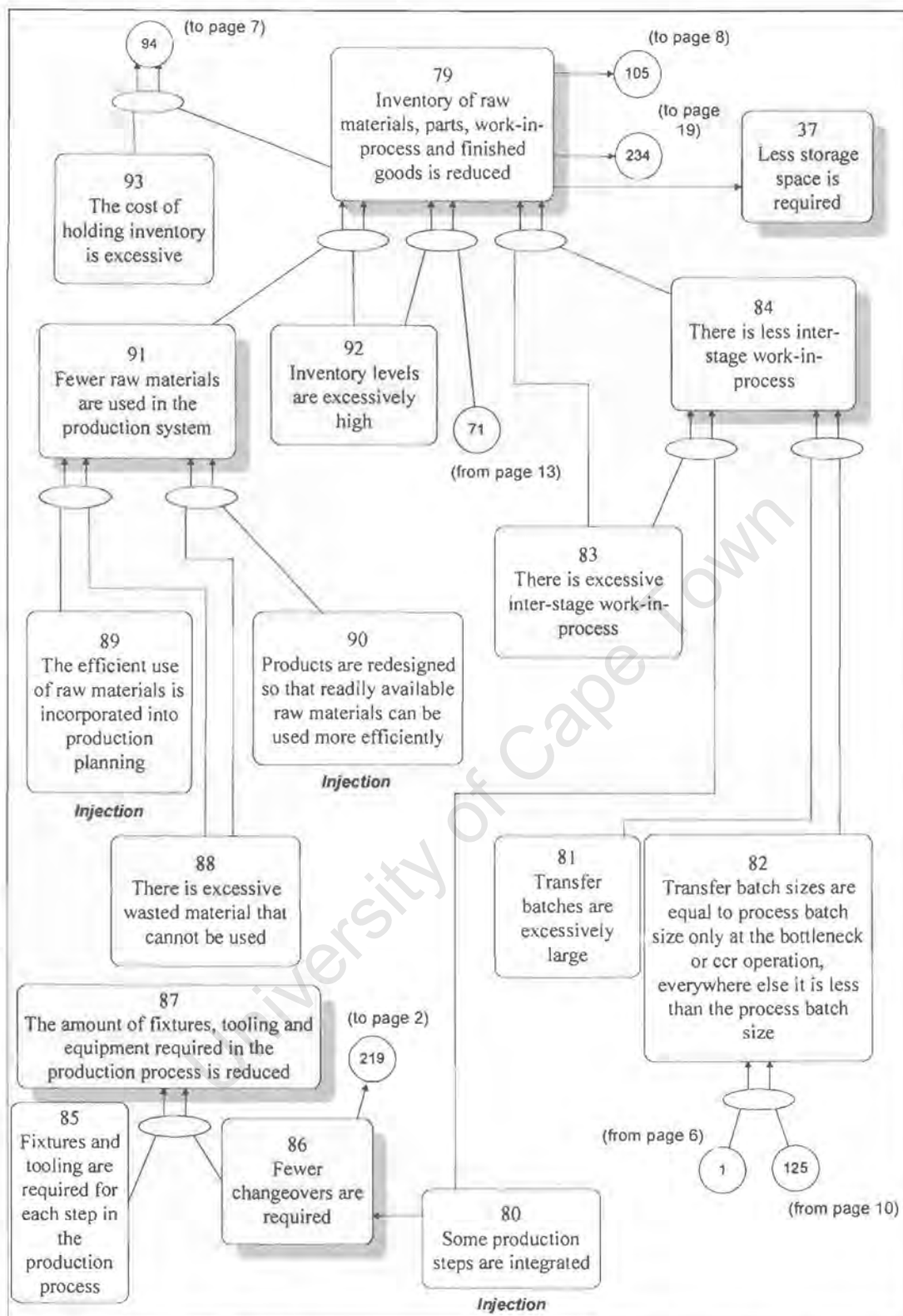


Figure 58-Page 12: Small Manufacturing Business Future Reality Tree:

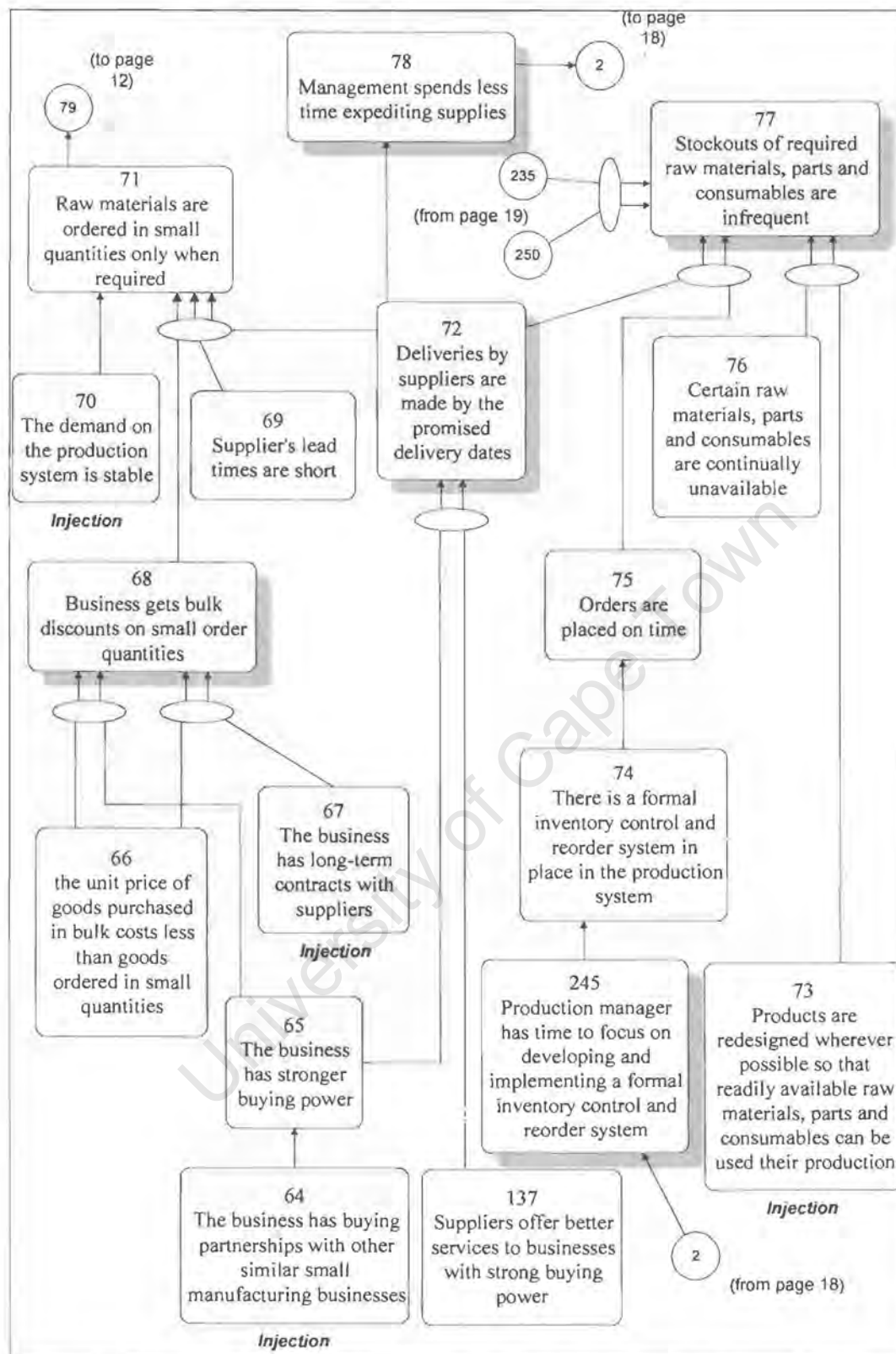


Figure 58-Page 13: Small Manufacturing Business Future Reality Tree:

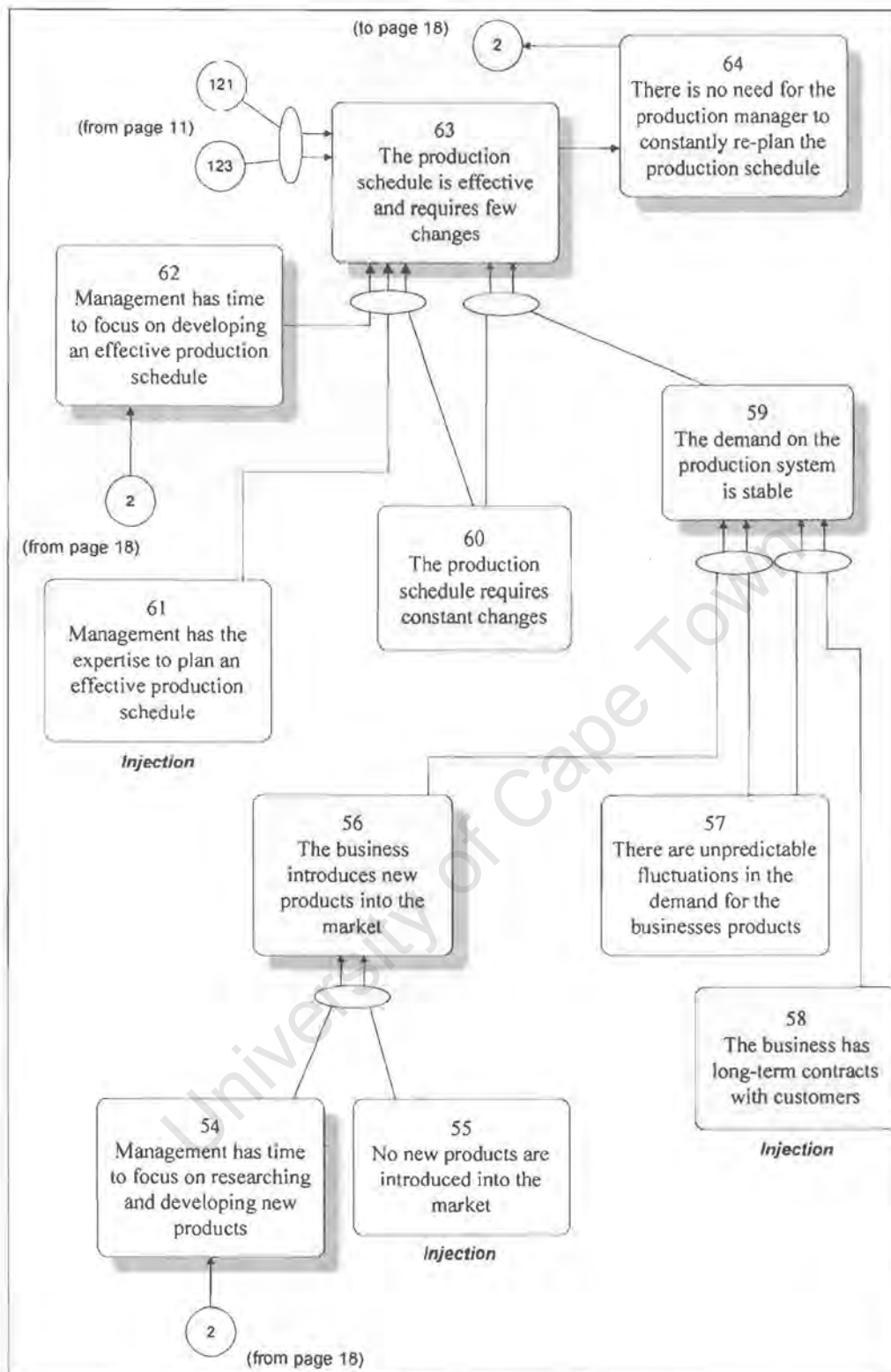


Figure 58-Page 14: Small Manufacturing Business Future Reality Tree:

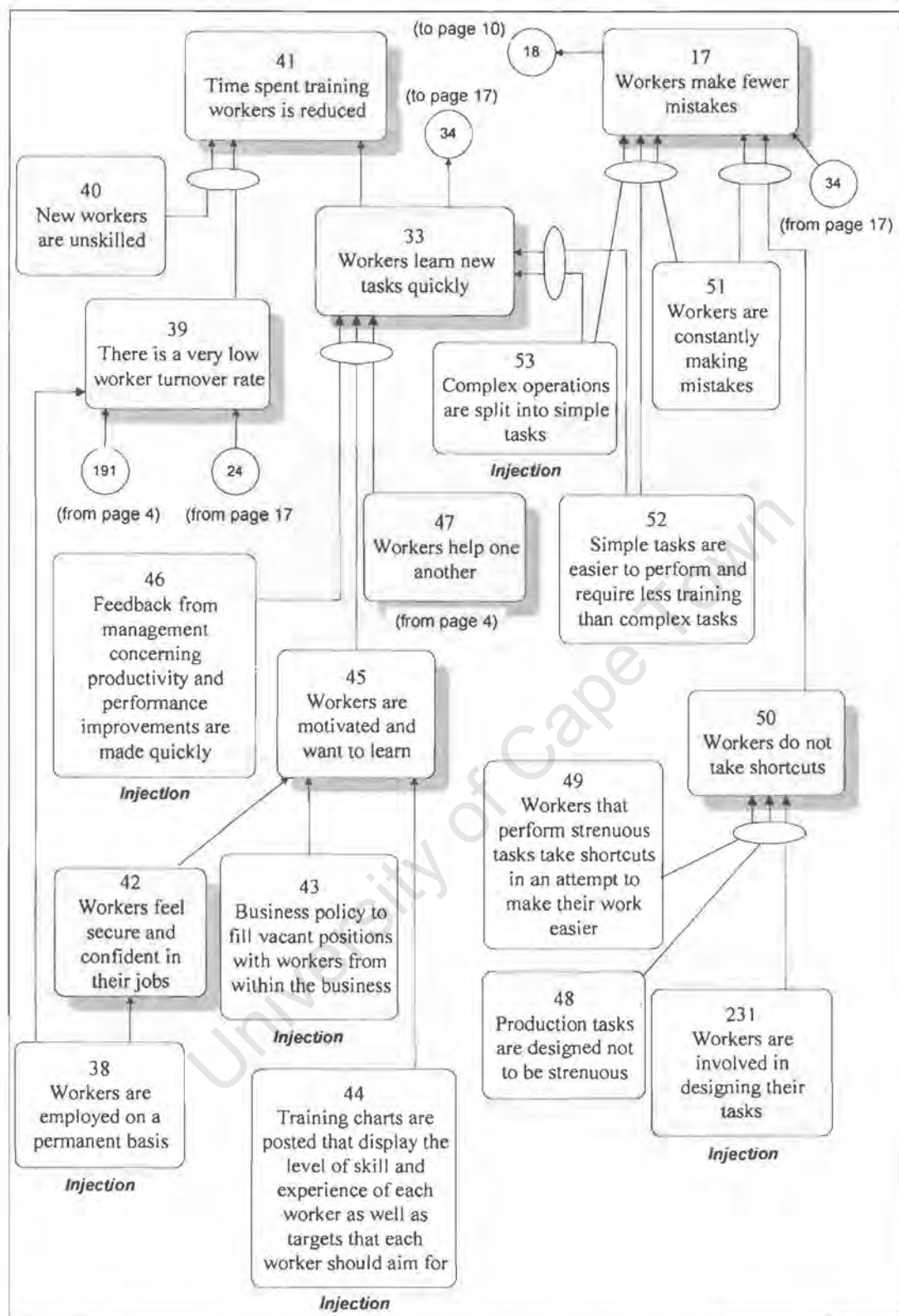


Figure 58-Page 15: Small Manufacturing Business Future Reality Tree:

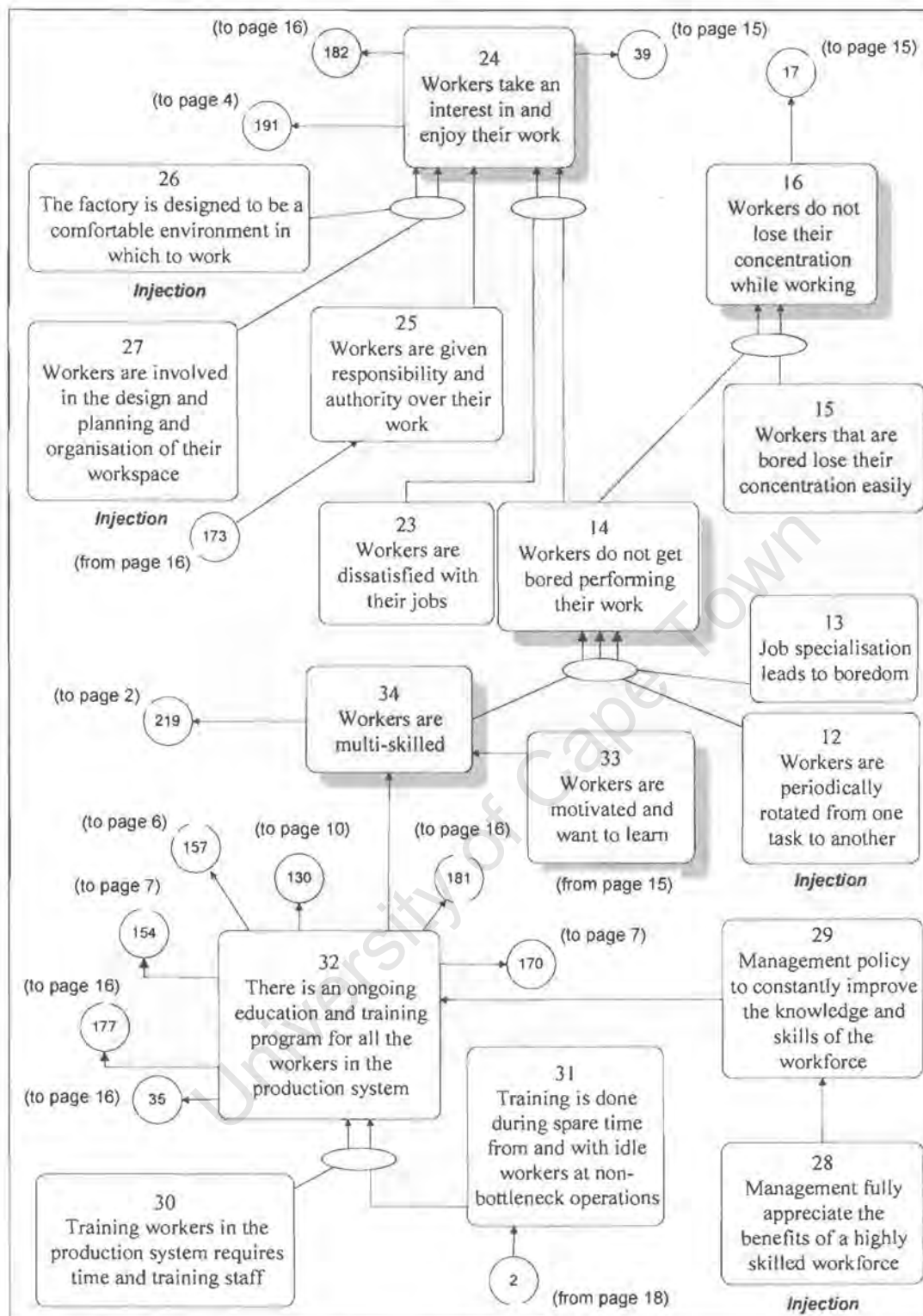


Figure 58-Page 17: Small Manufacturing Business Future Reality Tree:

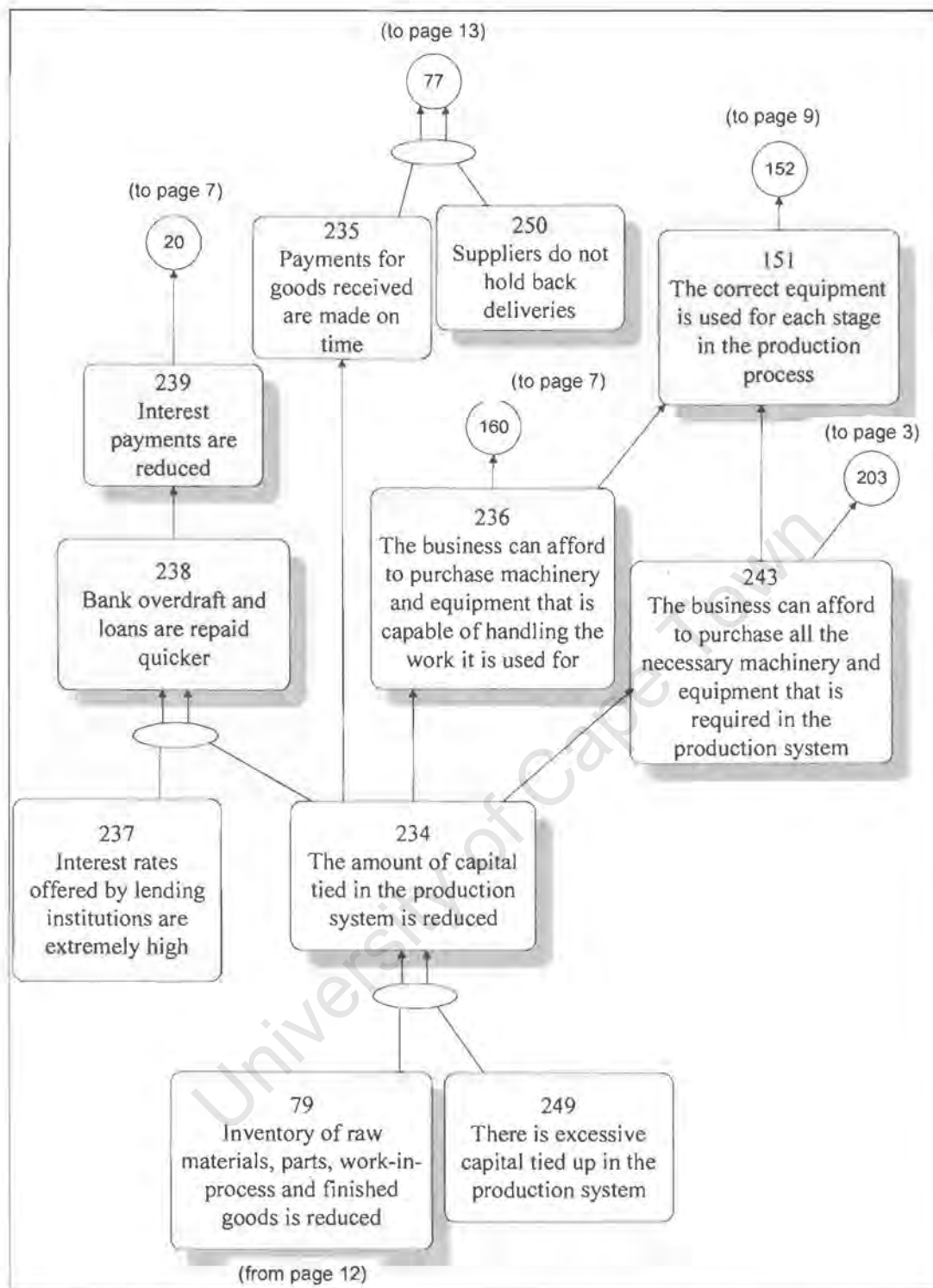


Figure 58-Page 19: Small Manufacturing Business Future Reality Tree:

10.2 Achieving Improved Manufacturing Performance:

The future reality tree highlights the following conditions that must be achieved in order to improve the manufacturing performance of small businesses.

Key condition 1. The production manager is sufficiently knowledgeable and skilled in the following areas of production and operations management.

- Product design and process selection
- Job design and work measurement
- Facility layout
- Project planning and control
- Inventory systems for independent and dependent demands
- Operations planning and control
- Materials management and purchasing
- System improvement methodologies, such as, Just-in-time, Total quality management and synchronised manufacturing
- Labour management
- Systems thinking, problem solving and decision-making.

Key condition 2. The factory is always tidy and organised.

Key condition 3. There is a productive relationship between management and workers, the workforce is motivated and their morale is high.

Key condition 4. The workforce is educated and multi-skilled.

Key condition 5. Quality is designed and built into the manufacturing system.

Key condition 6. Changeover times are constantly being reduced.

Key condition 7. Wasted material and energy is constantly being reduced.

Key condition 8. Machinery and equipment breaks down infrequently.

Key condition 9. Production is synchronised (flow is balanced).

Key condition 10. Suppliers are constantly being developed.

All these injections are interdependent which means that they cannot be achieved one at a time. Each condition must be accomplished incrementally and simultaneously.

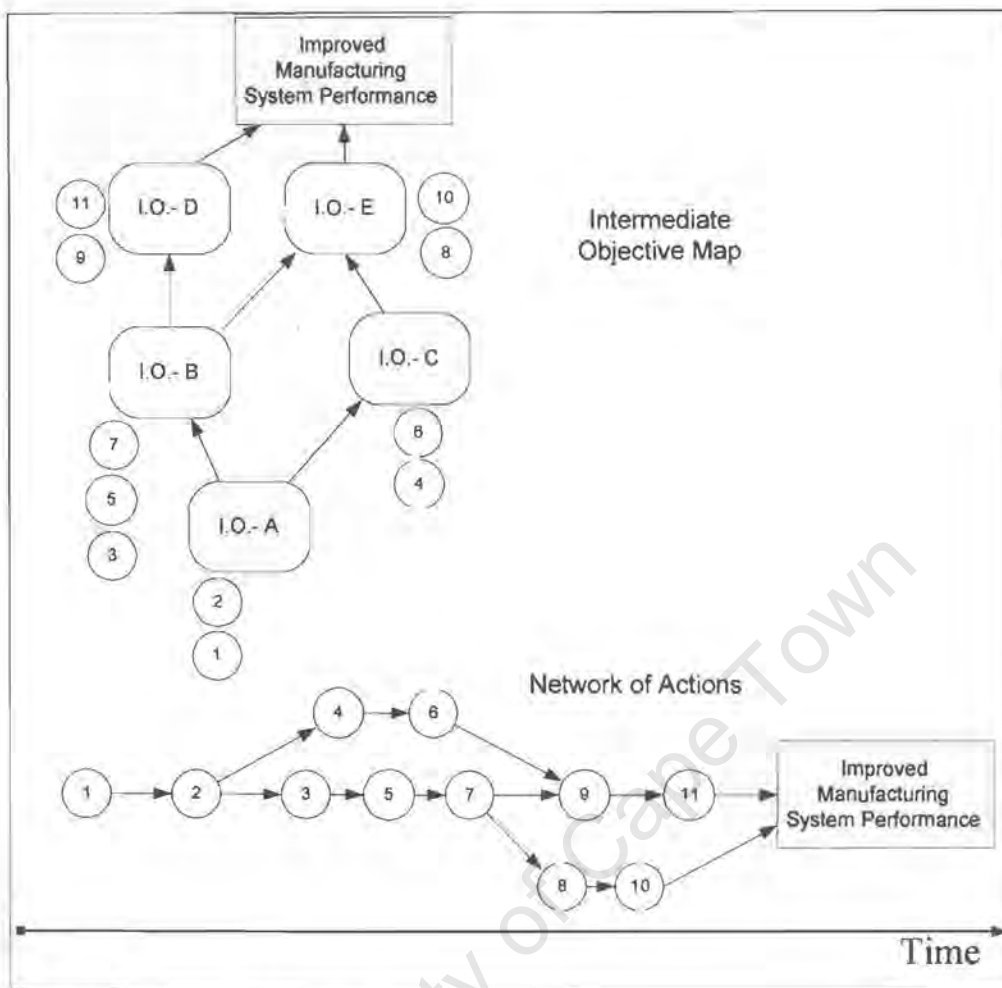


Figure 59: Networking of Actions

The basic steps that need to be taken to determine the correct sequence of actions required for improving manufacturing performance are shown in Figure 59: Networking of Actions.

- Step 1. The obstacles to or specifications for achieving improved manufacturing performance are determined.
- Step 2. The intermediate objectives (I.O.) that will overcome each obstacle are stated.
- Step 3. The intermediate objectives are sequenced according to the dependencies between them.
- Step 4. The tasks that have to be completed to achieve each of the intermediate objectives are defined.

Step 5. The resources required for each task are identified and allocated.

Step 6. The tasks are organised into a network on the basis of start-finish relationships between the different tasks.

The following list provides some examples of the specific actions that are required to translate these conditions into desirable effects.

Key condition 1. The production manager is sufficiently knowledgeable and skilled in the all areas of production and operations management as well as all general business management.

- 1.a. The production manager must realise that in order to improve the performance of his or her manufacturing system he or she must continuously improve his or her management skills and expertise.
- 1.b. The production manager must sacrifice time before or after work for further education. If the production manager has not had formal production and operations management training he or she must undergo planned production and operations management training.
- 1.c. Production managers who have limited knowledge in other business functions, such as, marketing and sales management, financial management and business administration, should attend a course on general business management. Ideally, any training should be specifically designed for small business management.
- 1.d. Production managers should constantly improve their expertise and knowledge base by reading production and operations management literature. Production managers with a broader scope of knowledge will have a greater variety of ideas for solving problems.

Key condition 2. The factory is always tidy and organised.

- 2.a. The production manager must realise that cleaning and organising activities are the most basic quality and productivity enhancement activities and that cleaning and organising should be ongoing.

- 2.b. The last five minutes of each day should be set aside for workers to clean and organise their workspaces and surrounds. The workers must use this time to throw away any scrap paper, cardboard, plastic, material and cigarette butts that are lying on the floor, on workbenches or on equipment.
- 2.c. Bins should be placed at every workstation. The bins should be cleared regularly and should never be left to overflow. Wherever possible the bins should be placed at the point where the waste is produced, for example, underneath a guillotine so that off-cut material falls directly into it.
- 2.d. Things, such as, scrapped or obsolete materials, components, products, tools, fixtures, equipment, shelving and workbenches, that are not going to be used in the foreseeable future should be thrown away or sold. The production manager must consult with the workers to ensure that nothing they need is discarded.
- 2.e. The production manager must develop a set of guidelines for each worker to follow in order to keep their workspaces clean and organised.
- 2.f. Workers must be educated about the importance of, and the need for a clean and organised working environment. Every worker should be responsible for keeping their work area tidy and organised. The workers should be encouraged to make suggestions for improving their areas. There should be some sort of evaluating criteria for straightening. Workers who are doing an exceptional job must be rewarded for their efforts. For example, a monthly draw can be held with the participants being the workers who have kept their workspaces tidy and organised.
- 2.g. The production manager must set aside some time during working hours as well as after working hours to plan, develop and implement procedures for keeping the factory organised and tidy.
- 2.h. Nothing should be stored directly on the floor, on or underneath workbenches, on machinery and equipment, in passageways or against walls. Clearly visible, easily accessible designated storage racks for tools, fixtures, and patterns must therefore be manufactured and installed. The workers who use these items must be involved in determining where the most productive storage areas should be, in making them and in setting them up. Workers that are not happy with where the storage areas are will not use them willingly.

- 2.i. High use tools should be colour-coded to make them easier to find and replace and should be kept close to where they are regularly used. Low use tools, fixtures, patterns and other equipment should be kept in a storeroom.
- 2.j. Workers must be able to find everything at a glance. Doors and side panels should be removed from cupboards and cabinets.
- 2.k. Inventory of similar parts that are not going to be used immediately, should be stored together in definite accessible areas regardless of where they were last processed. These areas should not be too far from where they will be processed next.

Key condition 3. There is a productive relationship between management and workers, the workforce is motivated and their morale is high.

- 3.a. The production manager must understand that the workers are the most important resource in the business. In order to maximise the effectiveness of this resource the workers full capabilities, physical and mental, must be utilised. Workers must be treated as human beings and not as human machines.
- 3.b. The production manager must set aside time to develop and implement an easy-to-use suggestion system in the factory.
- 3.c. The production manager must explain the need for the suggestion system, how it works and must continually encourage the workers to put their ideas forward as suggestions. As many workers do not feel comfortable writing or do not know how to write, the production manager should help these workers get their ideas written down. Workers that make useful suggestions should be involved in implementing the suggested changes and should be recognised and rewarded for their efforts.
- 3.d. The production manager should consult other production managers who have implemented successful suggestion programs.
- 3.e. Weekly meetings should be held between the production manager and the workers where suggestions can be discussed.
- 3.f. Workers should always be treated with respect and should never be put into situations where their dignity is compromised.
- 3.g. Workers should be employed on a permanent basis rather than as casuals or on limited duration contracts, after proving themselves.

- 3.h. To prevent workers from becoming bored and from losing interest in their work workers should be periodically rotated from one task to another.
- 3.i. A schedule of assignments must be posted each day.
- 3.j. Activities, such as, supervising and checking incoming deliveries, checking inventory levels, expediting work through the manufacturing system, supervising the collection of goods leaving the plant and other operational activities that management currently perform, should be given to the workers to do.

Key condition 4. The workforce is educated and multi-skilled.

- 4.a. The production manager must realise that in order for the workers to assist in improving the performance of the manufacturing system there must be an ongoing training and education program for every worker in the system. The program should cover physical skills required in the production system as well as problem solving and decision-making skills.
- 4.b. Training and skill charts, similar to the example shown in Figure 60, should be posted in highly visible work areas that show the level of competence of each worker in each operation in the process as well as training goals for each worker.

Name	Operation					
	Drill Press	Folder	Mig Welder	Grinder	Roller	Bender
Niel	⊙	○	⊙	⊙	⊙	○
Robert	⊙	⊙	○	✗	○	○
Arthur	✓	✓	⊙	✗	✗	✗
Marcus	○	○	○	⊙	✗	✓
Joseph	✗		✓	✗	✗	✓
John	○	⊙	✗	✓	✓	⊙
<p>⊙ Perfectly mastered and can train others</p> <p>○ Can run the station flawlessly</p> <p>✓ Can run the station with help and supervision</p> <p>✗ Cannot run station yet</p>						

Figure 60: Training and Skill Chart

- 4.c. Training should be done within the business. If nobody is skilled enough or able to train the workers then training should be outsourced. Training offered by suppliers of machinery and consumables should be used to reduce the cost of outsourcing training the. Another way of reducing training costs is by forming training partnerships with

other similar small manufacturing businesses. Workers can then spend time working and learning new skills in the training partner's production system.

4.d.Planned idle time should be used to train and educate the workers.

4.e.Feedback concerning productivity and performance improvements must be given quickly.

4.f. The business should have a promotional policy where workers from within the businesses fill vacant positions.

Key condition 5. Quality is designed and built into the manufacturing system.

5.a.The production manager must set aside time to develop and implement a quality improvement and assurance program.

5.b.The production manager and workers must identify and list all the operations in the production process that could possibly be a cause of poor or inconsistent product quality. Generally, operations that are difficult or strenuous to perform or operations that require constant measuring and marking, particularly when process batches are large, will result in substandard or inconsistent work.

5.c.The production manager must design and develop fixtures, patterns, jigs and tools that are easy to use and that can be quickly set-up accurately. It is critical that the workers who will use these items are involved in their design and manufacture. The simple fixtures, patterns, jigs or tools should be made first. Once the workers have had sufficient training they should manufacture improved fixtures, patterns, jigs and tools. These fixtures, patterns, jigs and tools should wherever possible, be made from existing scrap or obsolete materials, components or tools to prevent any further major investment in materials. The workers should use their planned idle-time to make these items. The capability of the production system and the workforce must always be taken into account when designing these items.

5.d.Workers must be responsible for the quality of their work. Subsequently, workers themselves must perform all the necessary inspections on their work before transferring them to the next operation. The workers must be given the means, which includes, adequate training, inspection tools, an understanding of the exact standards, and support from management to be able to carry out effective inspection.

- 5.e. As mishandling of work also results in poor or inconsistent quality, strenuous operations or operations that require excessive handling should be simplified, split up or the amount of handling reduced. For example, an item that is heavy and must be manually turned over and around to be worked on should rather be bolted to a frame that can be easily rotated.
- 5.f. The distance between operations should be reduced and trolleys should be used to transport work from one operation to the next to reduce the chance of work being mishandled and damaged between operations.

Key condition 6. Changeover times are constantly being reduced.

- 6.a. The first step in improving production performance is to understand that overproduction not only results in excessive inventory and carrying costs but also in other forms of waste, including, motion, rework and scrap, stock, work-in-process, and transport.
- 6.b. The production manager must design and develop fixtures, patterns, jigs and tools that can be quickly and accurately set up. It is critical that the workers who will use these items be involved in their design, development and manufacture. The changeovers at bottleneck operations should initially be focused upon. These fixtures, patterns, jigs and tools should be made from existing scrapped or obsolete materials, components and tools and should be made during the workers planned idle time. Workers should receive quick changeover training as part of their planned education and training program. As the workforce becomes more skilled and their understanding of the importance of reduced production lead-time improves, more of the design, development and manufacture of these items should be performed by them. The workers should not however, be allowed to make changes without consulting the production manager or whoever is in charge of the improvement process.
- 6.c. Charts that show current changeover times and target times should be posted above or near each piece of machinery and equipment. Written and displayed goals are more likely to be achieved than unwritten goals.

6.d.Products should be redesigned to use components that do not require processing where long-changeovers exist.

Key condition 7. Wasted material and energy is constantly being reduced.

- 7.a. The production manager and the workers should draw up a list of every form of waste. This list should then be used to develop a systematic plan for eliminating the waste identified.
- 7.b.As the material cost makes up a large portion of the overall production cost the use of raw materials, components and consumables should be carefully planned to reduce waste. For example, instead of cutting material for a product and leaving the off-cut material for later use, the material requirements of a number of various products should be considered for the most effective use of materials.
- 7.c.Products should be redesigned, wherever possible, so that readily available raw materials and components can be used more effectively. Only the absolutely necessary materials, components and parts should be used. For example, a shorter bolt should replace a bolt that extends from its nut.
- 7.d,Workers should be educated about what waste is, how to identify it and the importance of reducing it. Once workers understand the concept of waste and the need for eliminating it they should be involved in identifying it, through the suggestion system, and eliminating it. Special attention should be placed on educating workers so that they understand that inventory can and must be reduced. Once this is in progress a planned program should be started where every worker can participate in lowering inventory.
- 7.e.The size of both transfer batches and process batches must be reduced. Reducing the size of process batches reduces the amount of scrap produced at an operation that is incorrectly performed, while reducing the size of transfer batches speeds up feedback about quality problems. Process batch sizes should only be reduced once changeover times are reduced. A carefully planned material handling system must be in place to cope with the additional handling caused by smaller transfer batches.
- 7.f. Workers must understand the importance of “doing things right the first time” and must know what is acceptable and what is not. There must be clearly defined,

understandable and recognisable quality standards for every step in the production process. The standards must be objective rather than subjective. These standards should be posted at each workstation along with a sample of what is, and what is not acceptable.

- 7.g. Simple and easy to use inspection tools, such as, go no-go gauges, should be developed and used to ensure that bad parts are identified quickly and not processed further. Once again, the workers who will have to use the inspection tools should be involved in the design, development and manufacture of the inspection tools.
- 7.h. Wasted motion should be reduced. Each operation should be broken down into its component motions and examined. As wasteful motions are discovered the workers should formulate corrective action plans for eliminating it.
- 7.i. Carrying inventory back and forth and loading and unloading shelves or storage bins must be reduced.
- 7.j. Production operations must be scheduled effectively and coupled to ensure that no planned production time is wasted due to workers waiting for parts or tools they require.
- 7.k. Quality inspection must be performed in front of the first operation to ensure that no substandard material is used in the manufacturing system.
- 7.l. Storage racks for parts and tools must be situated close to where the parts or tools will be used to reduce time spent by workers walking around. Furthermore, parts and tools should always be kept in their designated storage places to reduce time spent by workers searching for the parts and tools they require.

Key condition 8. Machinery and equipment is breaks down infrequently.

- 8.a. The production manager should conduct research on how to maintain the machinery and equipment used in the production process.
- 8.b. Workers must be trained to use the machinery and equipment correctly. Workers that are not competent in operating machinery and equipment should not do so without the supervision of a competent worker.

- 8.c. Fixtures, such as, movement stops, cut-out switches and cords, and protective coverings, should be developed and made that prevent the machinery and equipment from being incorrectly used.
- 8.d. Workers should be trained to perform simple preventative maintenance tasks, such as, cleaning the machinery and equipment, lubricating joints, bearings, and shafts, performing oil changes, and checking and tightening fasteners. A preventative maintenance time schedule that shows when these tasks should be performed must be kept for every piece of machinery and equipment.
- 8.e. Once workers are competent in using the machinery and equipment and in performing the basic maintenance tasks they should be given responsibility for the machinery and equipment that they regularly use. Workers should be rewarded for maintaining the machinery and equipment that they are responsible for.

Key condition 9. Production is synchronised (flow is balanced).

- 9.a. Process-flow charts that begin with the preparation of the raw materials and end with the final product must be written up for every product. The charts must include average processing times that inventory should remain at each operation, and in transit between operations. Comprehensive time studies should therefore be performed for all the operations in the production system. These times should be used to schedule production as opposed to using roughly approximated times. As the production process becomes more organised the time studies will become more accurate.
- 9.b. The focus of the production manager must shift from ensuring that the efficiency of every element within the production system is high to ensuring that the efficiency of the overall system is high. A pull-type production scheduling system, such as, the drum-buffer-rope scheduling system, should be used as opposed to a push-type production scheduling system. Figure 61: The Drum-Buffer-Rope and Just-in-Case Production scheduling systems, below, shows the basic concepts of the drum-buffer-rope logistical system and the difference between it and the conventional push-type production scheduling system.

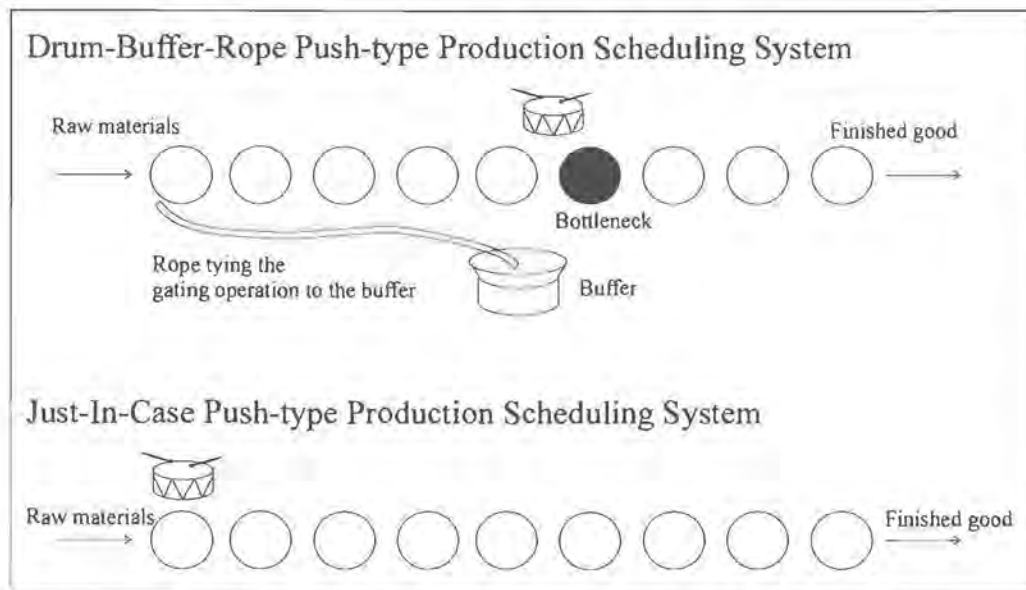


Figure 61: The Drum-Buffer-Rope and Just-in-Case Production scheduling systems

The system bottleneck dictates the rate of production of the entire system. Its production rate therefore serves as the drumbeat for the entire system. A time buffer that contains just enough inventory needed to prevent the bottleneck from becoming idle is placed in front of the bottleneck. The buffer is there to protect the bottleneck against disruptions and delays caused by operations before it in the process. In order to ensure that the inventory does not grow beyond the level dictated by the buffer, the rate at which material is released into the system must be limited. A rope (feedback system) is therefore tied from the bottleneck to the first operation in the system.

9.c. The implementation of a drum-buffer-rope scheduling system is a complex and difficult process. It is highly recommended that production managers study the relevant literature covering synchronised manufacturing and the implementation of the drum-buffer-rope production scheduling system. The following recommendations will help start the process.

9.d. Identify the system bottlenecks by observing the process and by talking with workers. Comments such as “I am always waiting for parts” or “They are feeding me more work than I can possibly do and I can’t keep up” point out bottleneck operations. Bottleneck operations tend to have extremely large working process in front of them waiting to be processed. As the majority of small businesses covered by the research

have disconnected line type flow the bottleneck operation tends to change with the varying demand placed on the system. Notes should be kept of which operation becomes the bottleneck for particular production requirements and particular product mixes.

- 9.e. The bottleneck should dictate the production schedule, based on market demand and on its own potential. The schedule for succeeding operations should be derived accordingly while the schedule for the preceding operations should support the buffer and thus be derived backwards in time from the bottleneck schedule. Material must only be released into the system and processed according to the schedule determined by the bottleneck. Material must never be released into the system to keep workers busy.
- 9.f. To ensure good due date performance the sequence of production at the bottleneck operation should be carefully planned. Work at the bottleneck should be scheduled forward in time from the present. What is to be produced, how much is to be produced and how long it will take must be considered. The earliest customer due date should be used to determine the order in which products are produced at the bottleneck. If the time to complete different products after they have been processed by the bottleneck or if the bottleneck feeds more than one part to the same product or if major changeovers are required, then sequencing the bottleneck is more complicated. In the first instance, products that have longer processing times after the bottleneck should be processed first. In the second instance, there is no need to use the customer due date in choosing the sequence, since all the parts have the same due-date. In the third instance, The process batch at the bottleneck should be increased, thereby reducing time lost to changeovers, to supply the market demand of a particular product for several days.
- 9.g. As the bottleneck limits the throughput of the system and controls the due date performance of the system the focus of improvements should be directed at it. The following actions should be taken to limit wasted processing time at the bottleneck.
- Process batch sizes should be large at the bottleneck operation
 - Preventative maintenance should be performed during breaks or during changeovers

- Material and parts must be inspected in front of the bottleneck operation, by a non-bottleneck worker, to prevent it from processing bad parts
- The bottleneck operation must be set-up correctly to prevent it from producing bad parts
- Operations further up the process must not produce bad parts. Reworking or replacing these parts will cause additional load on the bottleneck
- Non-bottleneck workers should inspect the bottleneck's work
- Non-bottleneck workers should be moved to the bottleneck operation to cover for late or absent bottleneck workers
- Regularly used tools should be kept at the bottleneck operation
- Work and tools should always be brought to the bottleneck operation

9.h. In order to reduce the size of the inventory buffer in front of the bottleneck the preceding operations that causes the disruptions and delays should be improved.

9.i. There should be coupling points where work-in-process is stored at the end of each operation. Every worker should go to the coupling point preceding it to get the items that they need to work on. The production plans of each operation must be co-ordinated. Flashing lights, kanban cards or designated inventory levels at the coupling points are examples of methods that can be used to co-ordinate the production of each operation.

Key condition 10. Suppliers are developed.

10.a. A comprehensive list of all the suppliers used should be compiled. The information on the list must include the goods purchased from each supplier, the latest prices paid for these goods, payment terms required by the suppliers, the reliability of their deliveries, their lead times, the quality of their goods and the availability of the supplies.

10.a. The preferred suppliers (those that offer the best service) should be contacted to find out what other goods they supply besides those currently being purchased from them. This information should be used to eliminate the need for purchasing from

unreliable or problematic suppliers and to reduce the number of suppliers. The price of goods should be renegotiated wherever buying power increases.

- 10.b. New suppliers should be sourced if the present suppliers are unreliable or problematic. Do not expect to get high quality supplies at unreasonably low prices.
- 10.c. New sources of supplies should continually be investigated. These new sources do not necessarily have to be immediately used but may have to be used in the future.
- 10.d. Wherever possible, small or micro sized businesses should be preferred as suppliers. Although large businesses are generally cheaper, the potential for developing close and sound business relationships with small businesses is greater. Technical advice and leadership can be effectively traded with mutual benefit. Small businesses will be more willing to aid in the development of new products.
- 10.e. Exact requirements and specifications must be given whenever orders are placed or whenever instructions are given. The less specific the instructions, the greater the chance that the supplies will be unusable or not as desired.
- 10.f. Buying partnerships should be formed with other similar type and sized businesses. The potential increase in buying power should then be used as leverage to get better service from suppliers.

The problems associated with implementing these tasks are described in the next section.

11 CONCLUSIONS:

The following conclusions were drawn from the research carried out for this project.

1. Limited resources are ineffectively and inefficiently used.

The excessive amounts of waste, namely, wasted motion, movement, space, production time, materials, scrap and rework, energy and effort that were identified through the research, indicates that the limited resources available to small manufacturing businesses are in most instances ineffectively and inefficiently used. In relative terms, the actuality (the current achievement with existing resources and constraints) of the small business is considerably lower than its capability (the possible achievement using existing resources within the existing constraints) and its potentiality (what could be achieved by developing resources and by removing constraints).

2. The direct causes of waste.

The direct causes of waste identified through the use of the effect-cause methodology are as follows. These causes are effects of more fundamental root causes.

- The lack of 'built-in-quality' in the manufacturing process results in scrap and rework.
- Long, complex and inconsistent changeovers lead to the production manager making large process batches, in order to compensate for production time lost to changeovers, and to reduce the possibility of quality inconsistency from one batch to another. This, in turn, results in overproduction and subsequently, in high levels of work-in-process and in delays in production.
- The excessive amount of inventory of raw materials, parts, work-in-process and finished goods results in excessive space being required for storing it, in excessive time and effort for carrying, moving, packing and unpacking it, and in inventory becoming obsolete.
- The lack of preventative maintenance on machinery and equipment causes frequent breakdowns and subsequently, unplanned idle processing time.

- The lack of a skilled workforce results in operations being incorrectly performed, in scrap and rework, in workers having to be constantly supervised and in machinery and equipment being misused and abused and subsequently, in frequent breakdowns.
- Poorly designed work and operating methods result in an excessive amount of unnecessary motion and effort and in scrap and rework, particularly where tasks are difficult or strenuous.
- The lack of effective production schedule and control methods results in workers waiting for materials, parts or partially worked items to continue their work, and in workers waiting while the machinery and equipment they need is being used by other workers.
- The lack of definite designated storage places for tools and parts results in workers wandering around looking for tools and parts that they need to continue their work.
- The lack of effective material planning results in material being used inefficiently.
- Management's policy of purchasing the cheapest supplies, or purchasing from suppliers offering the longest credit terms, often result in substandard supplies being purchased that require additional unplanned corrective work.

3. Root causes are remote from their effects.

The effect-cause methodology of the current reality tree is useful in identifying the causes of undesirable effects that production managers must constantly deal with. These causes are the high leverage points in the system where the greatest achievements can be obtained with the least effort and resources. Furthermore, the current reality tree shows that root causes are remote from their effects.

Root cause 1. Production managers lack the following knowledge or skills that are necessary for managing their manufacturing systems effectively:

- **production planning and organising skills,**
- **motivating and leading skills,**
- **problem solving skills,**
- **production and operations management skills, and**
- **general business management skills.**

The lack of knowledge and expertise results in,

- ineffective problem solving,
- ineffective planning and forecasting,
- ineffective production scheduling,
- ineffective financial budgeting and control,
- an ineffective inventory reorder and control system,
- an ineffective material handling and storage system,
- an ineffectively laid out and organised manufacturing process,
- a poorly motivated production workforce,
- poorly designed work and operating methods and procedures,
- a confrontational relationship between management and workers,

This root cause possibly results in no attempts being made at improving the performance of manufacturing systems as the production manager does not know what needs to be changed in the system or what to change things to.

Root cause 2. Production managers do not understand the principles of systems thinking and its use in problem solving and in managing their manufacturing systems.

The research showed that the greatest potential benefit of using the systems thinking approach in managing the manufacturing system, is that the system constraint, the area that will yield the greatest improvement if changed, can be identified and focused upon. This is essential in managing small businesses where the resources are so limited. By using the systems thinking approach to problem solving, the root cause of problems can be identified and focused upon rather than merely reacting to these problems. For example, a production manager may believe that production lead times are too long and would like to reduce them. Instead of analysing the problem systematically, the production manager reacts to this problem by increasing batch sizes, thinking that less changeover time will be required resulting in quicker lead times of orders. This production manager does not realise that by increasing

inventory, further delays will result in production thereby further increasing production lead times as well as increasing the likelihood of other seemingly disconnected problems, such as late notification of quality problems and increased scrap and rework. Figure 62: Fixes That Fail, shows the structure of this problem. An action is taken or a policy is put in place that is effective in the short term but has unforeseen long-term undesirable effects, which may require even more use of the action or policy.

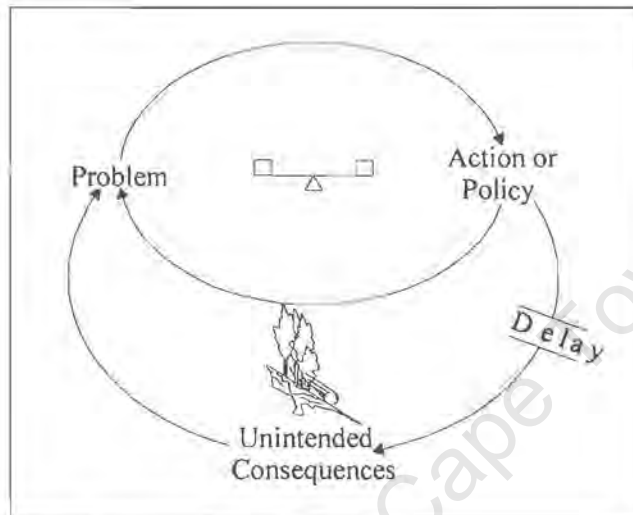


Figure 62: Fixes That Fail

The cause of the problem has been ignored and therefore any attempt at reducing current manufacturing lead times will be unsuccessful. In this instance the large process batch sizes was the cause of long manufacturing lead times and should therefore be reduced.

Root cause 3. There is limited management staff in small manufacturing businesses.

This means that the production manager has to perform non-production related activities, such as financial management, general business administration and marketing of their business's products, as well as performing all the activities necessary for managing his or her manufacturing systems. Consequently, the production manager does not have enough time to focus on managing their manufacturing systems. This problem is compounded by the fact that the production manager spends a large amount of his or her time expediting work through their

manufacturing systems, supervising workers, training workers, performing physical tasks in the process and inspecting quality. This results in only some activities being effectively performed with others being ignored or incompletely and ineffectively performed. Furthermore, as time is so limited and so ineffectively used the production manager can never focus on and fully understand the dynamics of problems, making it impossible for them to formulate effective solutions. Subsequently, the production manager spends his or her time unproductively, reacting to undesirable effects (fire fighting) rather than change activities.

Root cause 4. Lending institutions require unreasonable security and offer unaffordable lending rates for finance.

This, combined with excessive money tied up in the manufacturing system, results in a lack of working capital, which constrains running the business and results in high levels of management stress. The production manager reacts to this problem by,

- purchasing the cheapest supplies possible or from suppliers that offer the longest credit terms regardless of the quality of the supplies or of the reliability of the suppliers,
- hiring only cheap labour regardless of their skills,
- not employing additional management staff regardless of the workload on the existing staff,
- purchasing inexpensive machinery and equipment regardless of its quality or capabilities,
- employing workers on a temporary basis to avoid having any unnecessary workers when market demand decreased,
- making batch sizes large in order to reduce the setup cost per unit produced,
- purchasing raw materials in bulk in order to reduce the unit cost of supplies, and,
- pushing material into the system to ensure that every worker and piece of machinery and equipment is busy all the time, believing that high efficiencies bring down the unit cost of goods produced.

Although these reactive actions or policies are all aimed at reducing costs, the effects of these actions are not thoroughly considered, particularly the longer-term effects. These actions result in further capital being tied up in the manufacturing system or being wasted. For example, purchasing raw materials in bulk results in reduced material cost of goods but means that more capital is tied up in inventory. Similarly, having large process batch sizes results in less time being spent on changeovers and subsequently, in reduced setup cost per unit produced but means that inventory turnover is low resulting in a large amount of capital being tied up in inventory in the manufacturing system.

Root cause 5. Task and work variety in small business manufacturing systems is limited.

This results in workers having repetitive jobs and in limited opportunities for self-improvement and promotion. This results in an unmotivated and ill-disciplined workforce, in workers having no interest in their work, in a high rate of absenteeism and in a high staff turnover as workers find more enjoyable work with better opportunities elsewhere.

Root cause 6. Production managers have extremely set mental models (paradigms).

For example, a production manager thinks that because workers have no formal education they will not be capable of understanding the need for improvement, and of suggesting insightful and useful ideas for making improvements to the system.

Mental models influence how production managers understand their manufacturing systems and the actions they take. The research showed that powerful mental models result in resistance to change. For example, one fundamental injection that needs to be made for improving manufacturing system performance is that the workers have to be empowered to participate in shop floor problem solving and decision making.

This injection however, conflicts with the deeply set management assumption that the workers are incapable of understanding why improvements are necessary and how improvements should be made.

This root cause results in the workers having no involvement in decision making concerning their work and working environment, but rather in the management attitude of “do as you are told”. Consequently, the workforce is poorly motivated, unhappy and disinterested and there is a confrontational relationship between management and workers. The research showed that as production floor workers have a major influence on the performance of the system, improvements can only be achieved with a committed, motivated, multi-skilled and educated workforce.

If workers are effectively trained to identify problems, to formulate solutions to these problems, and are involved in problem solving, then there could possibly be more ideas for formulating solutions to shop floor problems and improving manufacturing system performance.

4. Conflicting requirements or conditions complicate problem solving.

The research showed that there are a number of problems that production managers encounter where at least two conditions or requirements have to be met in order for an objective to be achieved. For example, in order to reduce production costs the setup cost per unit produced must be reduced and carrying costs must also be reduced. The prerequisites for each of these conditions, have large batches in order to reduce setup costs and have small batches in order to reduce carrying costs, conflict as they are mutually exclusive. This problem as well as others described in the research are ‘solved’ by production managers making a compromise between the conflicting prerequisites or by meeting only one of the conditions. For example, the production manager may believe that reducing setup costs is more important than reducing carrying costs and therefore makes the batches as large as possible. This action is however, perpetuates the problem. The research showed that many of the production manager’s assumptions concerning the logical relationship between the objective and its requirements and the conditions and their prerequisites, are invalid.

The research showed that if production managers stop reacting to undesirable effects and spend more time consciously examining their mental models and looking at problems

from varying perspectives they will understand the dynamics of the problems better and will be able to formulate simple, productive solutions.

5. Implementing a process of change is extremely difficult and requires resources that are not available to small businesses.

The research showed that besides not knowing what to change in the manufacturing system or what to change things to, production managers did not know how to initiate an improvement process or implement changes as these root causes were all interdependent. The process described below shows how the root causes interact, thereby making it extremely difficult for production managers to initiate an improvement process of what to change?, what to change things to?, and how to cause the change?.

Before an improvement process can be initiated, production managers must have a thorough understanding of all aspects of production and operations management, of systems thinking and its use in problem solving and in managing their manufacturing systems, and their assumptions regarding logical relationships between causes and their effects must be valid.

In order for production managers to focus on these three prerequisites they must have sufficient time available to them. The limited number of management staff in small businesses results in there being insufficient time available during working hours for production managers to undergo formal training or for production managers to focus on understanding systems thinking. As production managers are trapped in the cycle of constantly reacting to undesirable effects they do not have time to stand back from their manufacturing systems and re-evaluate their mental models.

In order to have sufficient time to do these things, additional management staff must either be employed to cover some of the production managers tasks or production managers must spend less time on wasteful activities or the workers must participate in shop floor problem solving and decision making. As the business cannot raise capital from lending institutions there is insufficient working capital to afford to employ additional management staff without reducing waste and capital tied up in the

manufacturing system, which is one of the objectives of the improvement process to begin with.

In order for workers to participate in shop floor problem solving and decision making they must have the necessary skills and production managers must realise that their mental models concerning their workers abilities are invalid. There must therefore be a planned education and training program for all the workers. Once again, management must have the necessary knowledge to develop the program and sufficient time in which to develop and implement it.

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12 RECOMMENDATIONS:

The following recommendations were made based on the research carried out for this project, on the models that were constructed and on the conclusions that were drawn.

1. Small manufacturing businesses should adopt formal continuous performance improvement programs in order to compete with other similar small businesses and larger organisations. Throughput must be increased through reduced manufacturing lead times, improved product and service quality, reduced product prices, improved production flexibility, and inventory and operating expenses must be reduced. In order to adopt formal continuous improvement programs the root causes of undesirable effects must be eliminated.
2. Root causes 1, 2, 3 and 4 are all within the control of the production manager. The production manager can therefore take actions or implement policies to eliminate these root causes.
3. For root cause 1, production managers can undergo formal operations management training in order to broaden their knowledge and expertise and can gain the necessary skills that are required for managing their manufacturing systems productively,

For root cause 2, production managers can undergo training on systems thinking or can learn about systems thinking by reading relevant literature.

For root cause 3, additional management staff must be employed so that the production manager can focus on developing an improvement process and on manufacturing planning, organising, leading, motivating and controlling.

Furthermore, workers must participate in the improvement process in order to unload some of the production manager's activities and production managers must use their time more productively.

For root cause 6, production managers need to remove themselves from their routine of reacting to daily problems, step out of their manufacturing systems and consciously examine and re-evaluate their mental models.

Root causes 4 and 5 are not within the control of the production manager as root cause 4 is the result of an uncontrollable external policy and root cause 5 is a physical characteristic of small manufacturing businesses. The production manager can however, influence the effects of these two root causes. For example, in order to reduce the undesirable effects caused by the limited variety of tasks and work in small manufacturing businesses, workers can be periodically moved from one task to another, workers can be empowered, given responsibility and authority, to participate in shop floor decision making and the business can have motivational speakers for the workers.

Root cause 4 can be overcome by reducing the amount of waste in the manufacturing system. Reducing the amount of waste and capital tied up in production will result in more working capital becoming available and a reduced overdraft. Lending institutions are more likely to lend capital to businesses that have less debt.

4. The lack of readily available and affordable resources makes it extremely difficult for production managers of small business to take the necessary actions required to eliminate these root causes. In order for small manufacturing businesses to become more competitive and grow they must be assisted by outside sources that offer affordable and easily available management assistance. The following type of partnerships/organisations should be formed to assist small businesses.
 - Small manufacturing business partnerships that are made up of similar small manufacturing businesses that share information, management and technology.
 - A government and business assisted organisation that provides affordable assistance in managing and improving small businesses.

- Small business and tertiary education institutions (universities, technikons, technical colleges) partnerships where students assist small businesses in all management functions as part of their education.
5. Finally, it is recommended that further research be carried out on the formation of these business partnerships and assistance organisations.

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Appendix 1: SURVEY DETAILS.

University of Cape Town

SURVEY QUESTIONNAIRE FORM:

University of Cape Town



PRODUCTION MANAGEMENT SURVEY.

FOR ATTENTION: THE PRODUCTION MANAGER:

Successfully managing production systems of small or medium sized manufacturing businesses could be one of the keys to improving the South African economy in the near future. Presently many small and medium sized manufacturing businesses have problems that need to be identified and solved.

As a production manager of a small manufacturing business myself, I have chosen to research production management in small and medium sized manufacturing businesses for my masters degree in Engineering Management and request that you assist me by completing the attached questionnaire.

The aim of the research project is to determine the most common problems associated with production management in small and medium sized manufacturing businesses, and to determine their causes in order to improve production performance without the need for major resource inputs.

The attached questionnaire is therefore designed;

- To test whether or not your business is suitable for the research,
- To determine whether or not your business has the same basic problems as other small and medium sized manufacturing businesses, and,
- To get a basic idea of how your production system is managed.

The questionnaire should be completed by you, the production manager, or by one of your colleagues who understands the production system and the management thereof and posted back to me using the self-addressed envelope provided **before the 30th May 1998.**

Every respondent will receive a summary of the results and recommendations of the research project that will include methods of identifying problems, determining their causes and some practical means of eliminating them.

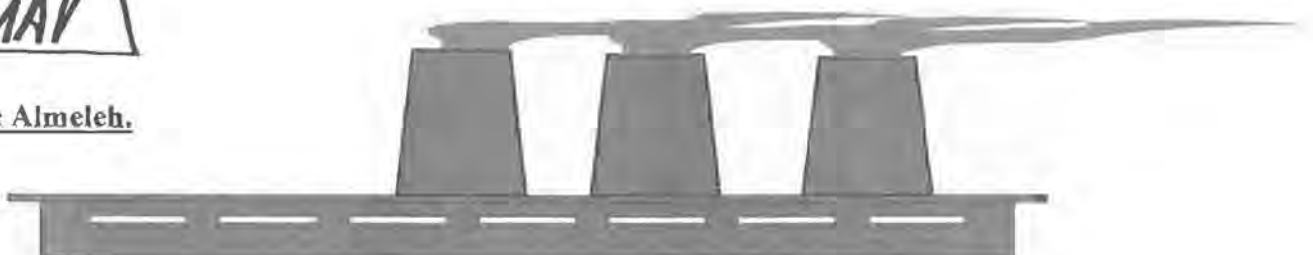
Your replies will be treated in the strictest of confidence, and never linked to your name or company.

If you have any queries concerning the questionnaire or the research please do not hesitate to contact me at home on (021) 439 4187, at work on (021) 511 8540 or by e-mail at almeleh@gem.co.za.

I thank you in anticipation for your contribution and look forward to sharing the findings with you.

Yours sincerely

Marc Almeleh.



SMALL MANUFACTURING BUSINESS PRODUCTION MANAGEMENT QUESTIONNAIRE:

There are two types of questions in this questionnaire. Please read each question and think about each answer carefully.



The first type closed-ended questions, are to be answered by simply ticking the box or boxes corresponding to the statement you select.

You may choose more than one answer per question.



The second type open-ended questions, are to be answered by writing brief notes as your answer.

SECTION 1: GENERAL BUSINESS DETAILS AND OPERATING BACKGROUND.

The questions in this section are designed to determine whether or not your company falls within the boundary of the research group.

QUESTION 1: Which of the following fields is your business concerned with?

- ☐ Manufacturing
- ☐ Wholesaling
- ☐ Importing
- ☐ Service Providing

QUESTION 2: Is your business associated with or a subsidiary of another business?

- ☐ Yes
- ☐ No

QUESTION 3: In which particular area is your manufacturing facility situated?

(For example, Paarden Eiland, Montagu Gardens, City Bowl, Ottery, etc.)

QUESTION 4: Is annual turnover of your business greater than R150 000?

- ☐ Yes
- ☐ No

QUESTION 5: How many persons, as an average, were employed in your business's production system through 1996/1997? Include production management staff, all temporary employees, sub-contractors, casual employees and permanent employees.

- ☐ Less than 5 persons
- ☐ Between 5 and 15 persons
- ☐ Between 15 and 40 persons
- ☐ Between 40 and 70 persons
- ☐ More than 70 persons

QUESTION 6: How many persons, as an average, were employed in the management, administration and marketing of your business's operations through 1996/1997? Include all temporary employees, sub-contractors, casual employees and permanent employees.

- ☐ Less than 3 persons
- ☐ Between 3 and 5 persons
- ☐ Between 5 and 10 persons
- ☐ More than 10 persons

QUESTION 7: Which of the following process technologies or combinations describe your production system.

- ☐ Labour intensive manufacturing operations.
- ☐ Automated manufacturing operations.
- ☐ Combination of mostly labour intensive operations with some automated operations.
- ☐ Combination of mostly automated operations with some labour intensive operations.

QUESTION 8: Which of the following types of production processes best describe your production system?

- ☐ Job type flow (constantly producing one-offs)
- ☐ Batch type flow (repeatedly producing one or more of the same standard items)
- ☐ Combination of batch and job flow.

QUESTION 9: What are the main products or product ranges your business manufactures?

SECTION 2: PRODUCTION SYSTEM & MANAGEMENT DETAILS.

The questions in this section are designed to get a basic idea of how your production system operates and how it is managed.

QUESTION 10: What is your position in the business?

- ☐ Business owner and production manager
- ☐ Partner or business part-owner and production manager
- ☐ Production manager
- ☐ Production supervisor or foreman
- ☐ Other. Specify below.

QUESTION 11: Which of the following tasks do you perform in the daily running of the business?

- ☐ Production planning and scheduling
- ☐ Supervising production
- ☐ Purchasing materials, equipment and consumables
- ☐ Reviewing production performance
- ☐ Production system administration
- ☐ General business administration
- ☐ Personnel management
- ☐ Debt collecting
- ☐ New product research and development
- ☐ New production methods research and development
- ☐ Sales and marketing
- ☐ Setting up machinery and equipment
- ☐ Physical production tasks (welding, cutting, assembly, etc.)
- ☐ Maintenance of machinery and equipment
- ☐ Other tasks. Specify below.

QUESTION 12: Which of the following statements best describe the layout of your production system?

- ☐ Similar equipment or functions are grouped together (e.g. all lathes in one area and all stamping machines in another)
- ☐ Workcenters are arranged according to the progressive steps by which the products are made with backtracking of work through the process.
- ☐ Workcenters are arranged according to the progressive steps by which the products are made with no backtracking of work through the process.
- ☐ Dissimilar machines are grouped in workcenters to work on products that have similar shapes and processing requirements.
- ☐ Equipment is arranged according to the space available in the factory.
- ☐ The production system is laid out in another way. State below.

QUESTION 13: Which of the following statements best describe the type of equipment and machinery used in your production system?

- ☐ Only specialised machinery and equipment.
- ☐ Mostly specialised machinery and equipment with some general-purpose machinery and equipment.
- ☐ Mostly general-purpose machinery and equipment with some specialised machinery and equipment.
- ☐ Only general-purpose machinery and equipment.

QUESTION 14: How do you determine the batch size of either a particular part or product to be produced?

- ☐ The production batch size is always the same as the order size
- ☐ The production batch size is determined by adding some stock items to the order size to gain better efficiencies and improve the economic order quantities
- ☐ The production batch size is determined by scheduling all operations for maximum capacity (no spare production time)

available)

- ☐ The production batch size is determined by scheduling all operations to obtain balanced flow through the system (no build up of material or work-in-process between operations except before a bottleneck operation)
- ☐ The production batch size is determined by another method. State below.

QUESTION 15: Which of the following statements apply to the material handling and material flow through your production system?

- ☐ Material and parts for each batch are kept together and only move from one operation to the next when all processing is complete on that batch.
- ☐ Parts and material that have been processed by one operation move to the next operation even if the other parts/material have not been processed yet.
- ☐ Parts and material flow from one operation to another in another way. State below.

QUESTION 16: On a scale of 1 to 5, 1 being only skilled (artisans) and 5 only unskilled (labourers), how would you describe the skill content of your production workforce?

1	2	3	4	5
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QUESTION 17: On a scale of 1 to 5, 1 being minor and 5 major, how would you rate the extent of the workers influence over their work environment?

1	2	3	4	5
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QUESTION 18: How are production employees remunerated for their work performed?

- ☐ Paid wages or a salary only
- ☐ Paid wages or a salary as well as financial incentives
- ☐ Paid wages or a salary as well as non-financial incentives
- ☐ Paid according to an incentive scheme only. Describe briefly below.

SECTION 3: PRODUCTION SYSTEM PROBLEMS & THEIR CAUSES.

The questions in this section are designed to find problems in production systems and to determine their causes.

QUESTION 19: Do you have clearly stated and set quality standards for goods produced in your production system and quality controls for operations performed?

- ☐ Yes
- ☐ No

If your answer is YES, briefly describe how you ensure the set standards and controls are adhered to.

If your answer is NO, briefly describe how you determine whether or not the goods produced in your production system are fit for shipment.

QUESTION 20: As a approximate percentage of the products produced in your production system, how many are returned due to being defective or substandard?

- ☐ less than 1%
- ☐ between 1% and 5%
- ☐ between 5% and 15%
- ☐ more than 15%

☐ unknown.

QUESTION 21: On a scale of 1 to 5, 1 being consistently above standard and 5 being consistently below standard, How would you rate the quality of goods leaving your factory?

1 2 3 4 5

Describe briefly what you believe to be the main causes of substandard quality of goods produced in your production system.

QUESTION 22: Who is responsible for checking the quality of parts and products produced in the production system?

- ☐ A quality controller
- ☐ The Forman or production supervisor
- ☐ The production manager
- ☐ The workers themselves
- ☐ Nobody
- ☐ Someone else. State below.

QUESTION 23: Where are quality problems or defects most often noticed in your production system?

- ☐ Defects are noticed before production begins (incorrectly supplied, substandard, damaged parts and material received from suppliers)
- ☐ Defects are most often noticed near the start of processing
- ☐ Defects are most often noticed about midway through processing
- ☐ Defects are most often noticed near the end of the processing
- ☐ Defects are most often noticed once processing is complete or as goods are being prepared for dispatch.
- ☐ Defects are noticed at varying stages through processing.
- ☐ Defects cannot be traced to one particular stage in processing.

QUESTION 24: Do you have set clearly defined standard work methods and procedures for:

- ☐ - A - All of the operations in the production process.
- ☐ - B - Some of the operations in the production process.
- ☐ - C - None of the operations in the production process.

If your answer is A, are the standard methods followed by the operators in the production process?

- ☐ YES
- ☐ NO

If your answer is B or C, describe briefly how do you ensure consistent quality of every batch of goods or parts?

QUESTION 25: On a scale of 1 to 5, 1 being always late and 5 being always on time, how would you rate the due-date performance of your production system?

1 2 3 4 5

Describe briefly what you believe to be the main causes of missed due-dates of orders from your production system.

QUESTION 26: As an approximate percentage, how much of the average weekly production time available is lost due to production worker absenteeism?

- ☐ Less than 2%
- ☐ Between 2% and 5%
- ☐ Between 5% and 10%
- ☐ More than 10%

Describe briefly how production worker absenteeism affects the following.

1) Production schedules and planning.

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2) Quality of goods produced in your production system.

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3) Due-date performance of the production system

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4) Level of stored material, work-in-process and finished goods in your production system.

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.....

5) Production system operating costs.

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6) Any other aspects of production management or of your production system.

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QUESTION 27: On a scale of 1 to 5, 1 being low and 5 being high, how would you rate the morale of your production workforce.

If your answer is either 1, 2 or 3, describe briefly what you believe to be the cause of the low or indifferent production workforce morale.

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If your answer is either 4 or 5, describe briefly the methods you employ to keep morale high.

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QUESTION 28: On a scale of 1 to 5, 1 being poor and 5 being excellent, how would you rate the discipline (attitude towards work and management, punctuality for work and adherence to instructions and company rules) of your production workforce.

If your answer is either 1, 2 or 3, describe briefly how the lack of discipline affects the following.

1) Production scheduling and planning.

.....

.....

2) Quality of goods produced in your production system.

.....

.....

3) Due-date performance of the production system.

.....

.....

4) Level of stored raw material, work-in-process and finished goods in your production system.

.....

.....

5) Production system operating costs.

6) Any other aspects of production management or of your production system.

QUESTION 29: As an approximate percentage, what was the turnover of production employees through 1996?

- ☐ Less than 5%
- ☐ Between 5% and 15%
- ☐ Between 15% and 50%
- ☐ Between 50% and 100%
- ☐ More than 100%
- ☐ Do not know

QUESTION 30: In which of the following ways were production employees turned over through 1996?

- ☐ Dismissal.
- ☐ Retrenchment.
- ☐ Retirement.
- ☐ Resignation.
- ☐ Absconding.
- ☐ Expiry of employment contract.
- ☐ Other. State below.

If production employees resigned or absconded state their reasons for leaving.

QUESTION 31: On a scale of 1 to 5, 1 being never achieved and 5 being always achieved, how would you rate the expected productivity levels achieved by your production workers?

1 2 3 4 5

If your answer is 1, 2 or 3, which of the following do you believe to be the cause of the low productivity levels achieved in your production system?

- ☐ Low morale of the workforce.
- ☐ Lack of skill and understanding of the job.
- ☐ Lack of motivation.
- ☐ Lack of effective training.
- ☐ Disregard for set standard work methods and procedures.
- ☐ Lack of effective communication between management and workers.
- ☐ Do not know.
- ☐ Low productivity levels have other causes. State below.

QUESTION 32: On a scale of 1 to 5, 1 being untidy (blocked passageways, disorganised storage, cigarette butts, scraps of paper and tools scattered around the factory floor) and 5 being tidy (clear passageways, clean floor, machines and equipment, tools in visible racks), how would you rate the cleanliness of your factory?

1 2 3 4 5

If your answer is either 1, 2 or 3, which of the following do you believe to be the cause of untidiness in the factory?

- ☐ Lack of formal factory floor organisation.
- ☐ Lack of effective training.
- ☐ Worker laziness.

- ☐ Disregard for instructions or standard procedures.
- ☐ Lack of effective communication between management and workers.
- ☐ Not enough time to clean the factory.
- ☐ No definite place for tools and or parts.
- ☐ Do not know.
- ☐ Untidiness of the factory has other causes. State below.

Describe briefly any problems that you believe are caused by an untidy factory shop floor.

QUESTION 33: Does work-in-process between operations, finished goods or partially finished goods disrupt material and work flow through your factory?

- ☐ Yes
- ☐ No

QUESTION 34: Are parts, material, work-in-process or finished goods ever misplaced, stolen or damaged during its wait between operations or in storage?

- ☐ Yes
- ☐ No

QUESTION 35: Are parts/material always ready for processing when required?

- ☐ Yes
- ☐ No

If your answer is No, describe briefly why parts are not always ready for processing when required.

QUESTION 36: Are parts, material or goods always being expedited (rushed through the production process)...

- ☐ To ensure everyone is busy working all the time.
- ☐ To replace missing, stolen, or damaged parts or goods.
- ☐ To complete late or urgent orders.
- ☐ For another reason. State below.

QUESTION 37: Which of the following statements best describe bottlenecks (the workcenters or operations that slow the production's output) in your production system?

- ☐ The same operations/workcenters constantly slow the entire production process.
- ☐ The operation/workcenter that slows the production process changes from one workcenter to another.
- ☐ The operation/workcenters that slow the production process cannot be pinpointed.
- ☐ There are no bottleneck operations in our production system.

QUESTION 38: Which of the following are the main causes of machine and equipment breakdowns in your production system?

- ☐ There is a lack of effective routine maintenance.
- ☐ The machinery and equipment is incorrectly setup and/or used - due to users inadequate training.
- ☐ The machinery and equipment is incorrectly setup and/or used - due to users disregard for instructions and/or negligence.
- ☐ The machinery and equipment is old and in poor condition.
- ☐ The machinery and equipment breakdowns due to other reasons. State below.

QUESTION 39: On a scale of 1 to 5, 1 being poor and 5 being excellent, how would you rate the following aspects of service received from your suppliers?

On-time deliveries from suppliers:

1	2	3	4	5
---	---	---	---	---

Quality of material, parts and goods supplied by suppliers:

1	2	3	4	5
---	---	---	---	---

General attitude of suppliers towards your business:

1	2	3	4	5
---	---	---	---	---

QUESTION 40: Describe briefly how your suppliers' service affects the following.

1) Production scheduling and planning.

2) Quality of goods produced in your production system.

3) Due-date performance of the production system.

4) Level of stored raw material, work-in-process and finished goods in your production system.

5) Production system operating costs.

6) Any other aspects of production management or of your production system.

QUESTION 41: Describe briefly how the lack of the following resources and skills affects the management of your business's production system.

1) Lack of capital.

2) Lack of management expertise.

3) Lack of management time available.

4) Lack of educated and skilled workforce.

5) Lack of effective communication between management and production workers.

6) Lack of other resources or skills, state below.

QUESTION 42: Describe briefly any other problems not discussed in this questionnaire that you believe are causes of,

- A) LATE DELIVERIES,
- B) SUBSTANDARD OR INCONSISTANT PRODUCT QUALITY, AND,
- C) INCREASED PRODUCTION COSTS.

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THANK YOU FOR YOUR TIME AND EFFORT

University of Cape Town

SURVEY SAMPLE FRAME:

University of Cape Town

Telephone No.	Company Name	Address		Postal Code	Faximile No.
5114317	DOVETAIL PRODUCTS		25 NATAL STREET	PAARDEN EILAND	7405
9307509	MICROFAB ENGINEERING		3 BOOMPIE STREET	PAROW	7500
7975490	CAPE HANDLE BAR		P O BOX 18353	WYNBERG	7824
5114679	SCIENTIFIC ENGINEERING		P O BOX 44	MILNERTON	7435
5116463	VENTAIR		30 LOWESTOFT STREET	PAARDEN EILAND	7405
5518122	PUBCRAFT	9 MARCONI PARK	MARCONI CRESCENT	MONTAGU GARDENS	7441
9316179	DOMESTIC GEYSER MANUFACTURERS		PO BOX 240	ELSIES RIVER	7480
588583	J P ALUMINIUM		PO BOX 12091	N1 CITY	7463
	FOLDO BLINDS		PO BOX 575	BELLVILLE	7535
7051795	LANCE DESIGNS		PO BOX 283	SOUTHFIELD	7880
	BRAVE NEW WORLD				
	JAM ART				
	CRAZY NAME COMPANY				
	TUFF TOYS				
5113143	CAPE FABRICATED METALS		PO BOX 32	PAARDEN EILAND	7420
9349733	ARCRITE ENGINEERING		PO BOX 24465	LANSDOWNE	7779
9498156	FLDDBROS STEEL MANUFACTURING		PO BOX 851	PAROW	7499
6916485	HOUTCRAFT		PO BOX 6246	WELGEMOED	7538
9035107	LECTRON MANUFACTURING		33 FABRIEK STREET	KUILSRIVER	7580
5103663	BK METAL		INDUSTRY STREET	PAARDEN EILAND	7405
9054029	W H ENTERPRISES	24 SBDC CENTRE	RANGE ROAD	BLACKHEATH	7580
4613460	WOODLAM MANUFACTURING		94 MACKENZIE STREET	GARDENS	8001
5101072	CANE TIME		PO BOX 315	HOWARD PLACE	7450
9513211	ALBERT MOORE		PO BOX 19	BELLVILLE	7535
5111702	CAPE DUTCH MOULDINGS		PO BOX 480	PAARDEN EILAND	7420
6960389	TUFF PLAYSTRUCTURES		P O BOX 73	CRAWFORD	7770
9033342	WOODCUTTERS		PO BOX 1259	KUILSRIVER	7579
470404	THE WOODSMITH		12 RAVENSCRAIG ROAD	WOODSTOCK	7925
9035169	FILLIES DOORS EXCLUSIVE		PO BOX 617	KUILSRIVER	7579
	AFFINITY INTERIORS		PO BOX 51562	V&A WATERFRONT	8002
9453291	CAPE SELECT FURNITURE		ELECTRON STREET	STIKLAND	7530
5560456	CASA NOSTRA INTERIORS		12 MARINE CIRCLE	TABLE VIEW	7441
9319224	ATLANTIC METAL PROJECTS		48 EPPING AVENUE	ELSIES RIVER	7490
9513881	METAL ART CREATIONS	UNIT 22 SAXEN PARK	GLUCOSE ROAD	BELLVILLE	7530
7973695	AQUALUX SHOWER DOORS		2 VENUS ROAD	WETTON	7780
9319204	AUROCAB MANUFACTURES		PO BOX 709	PAROW	7499
7974196	SAUNA KING		PO BOX 14426	KENWYN	7790
4481100	SAUNA & STEAM BATH MANUFACTURERS		PO BOX 15219	VLAEBERG	8018
5514923	MONTAGU FABRICATORS		PO BOX 28187	BOTHASIG	7406

7978487	MEGA-LITE		PO BOX 14512	WETTON	*****	7970251
4611669	BOB'S TOWBARS & TRAILERS		36 SIR LOWRY ROAD			
6964110	BEAMISH FIBREGLASS		7 ROSEDON ROAD	LANSDOWNE	7780	
7831672	AFRICAN RIVER KRAFT	56 HERON PARK	WILDEVOEL ROAD	KOMMETJIE	7975	7831427
5911611	HENK METAL INDUSTRIES		PO BOX 633	PAROW	7499	
7015363	INTERKRAFT FURNITURE MANUFACTURERS		PO BOX 350	STEENBERG	7947	7013464
9340717	SOUTHERN JOINERY		PO BOX 98	SOUTHFIELD	7880	9340805
9463222	ERGOFORM					9493221
	PETREL TOWBARS					
544330	EXQUISITE WROUGHT IRON WORKS					5350206
4186930	THE IRON DESIGN COMPANY					
6857777	ABSTAIRS		P O BOX 168	KUILSRIVER	7579	9030131
5103029	AIR MASTER		P O BOX 460	GATESVILLE	7766	
7628905	ALCAPE FENCING		P O BOX 161	SOUTHFIELD	7880	7627926
921987	ALPHA WELDING WORKS		P O BOX 150	BELLVILLE	7535	920922
546111	ALPINE LOUNGE		P O BOX 324	EPPINDUST	7475	546959
7058388	ANTHONY'S WELDING WORKS		10 PRESIDENT STEYN STREET	SOUTHFIELD	7800	
4611480	BALI BLINDS	MERKEL HOUSE	20 NEW MARKET STREET	CAPE TOWN	8001	454390
725428	BOB'S LIGHT ENGINEERING		11 MOCKEL ROAD	DIEP RIVER	7800	
9485102	BRAAIQUIP		1A NEUTRON STREET	STIKLAND	7530	9498841
5938331	BRASS FARTHING		P O BOX 275	MAITLAND	7404	5934648
5932123	BRASS KNIGHT		P O BOX 39750	MAITLAND	7404	5935289
452716	CANE COTTAGE		16 BARRACK STREET	CAPE TOWN	8001	452753
	CANE FURNITURE & BASKETS		255 VOORTREKKER ROAD	PAROW		
5931219	CANEMASTER CENTRE		455 VOORTREKKER ROAD	MAITLAND	7405	
9311196	CAPACK		P O BOX 12026	PAROW VALLEY	7503	9314434
5934110	CAPE SEATING MANUFACTURERS		P O BOX 825	MAITLAND	7404	5930904
9453291	CAPE SELECT FURNITURE		ELECTRON STREET	STIKLAND	7530	9492839
9322022	CAPE STEEL WORKS		46 RILEY STREET	BEACONVALE	7500	
9333103	CAPE WIRE & MESH		P O BOX 556	GOODWOOD	7459	9328834
546231	CASTLE CONTRACTS		P O BOX 384	EPPINDUST	7475	546238
479420	CASTLE FRAMING WORKS		P O BOX 232	SALT RIVER	7924	
9487482	CHAIRMANS	CHAIRMANS HOUSE	FARRAD STREET	STIKLAND	7530	
546338	CITY METAL PRODUCTS		P O BOX 118	EPPINDUST	7475	548236
4485030	CLASSICA UPHOLSTERY MANUFACTURERS	201 DEWAAL HOUSE	172 VICTORIA ROAD	WOODSTOCK	7925	
4481526	COASTAL METAL WORKS		5 FORGATE STREET	WOODSTOCK	7925	473718
9494121	CONNOISSEUR MOULDINGS		P O BOX 3620	TYGERVALLEY	7536	9493112
4488603	CORICRAFT		P O BOX 398	SEA POINT	8060	4485246
9331144	COROMA		P O BOX 106	HOWARD PLACE	7450	9329153
5119242	COTTAGE CASTINGS		P O BOX 199	PAARDEN EILAND	7420	5112066
7976695	DESIGN TECHNICS	WOODWORLD INDUSTRIAL PARK	CRET STREET	WETTON	7780	7976695

5930646	DESKING CONCEPT		14 6TH AVENUE	MAITLAND	7405	
9051503	DISPLAY FORCE		P O BOX 564	SANLAMHOF	7532	
238537	DOVETAILS		83 KLOOFNEK ROAD	TAMBOOSKLOOF	8001	
7041190	DURAFORM OFFICE FURNITURE		P O BOX 195	OTTERY	7808	7041206
312605	DYNAMIC STEEL WORKS	SBDC HIVE	EISLEBEN ROAD	PHILIPPI	7785	
5118540	ELECTRO PRODUCTS		P O BOX 146	PAARDEN EILAND	7420	5115865
966562	FAUL SUPPLIES		P O BOX 11	DURBANVILLE	7551	
7970660	FURNITURE MANUFACTURING CO.		36 FLAMINGO CRESCENT	LANSLOWNE	7780	7622337
7018739	GATE MASTER		P O BOX 59	STEENBERG	7947	7010456
9334205	GATEWAY STEEL		P O BOX 94	THORNTON	7485	9336401
9318129	GENERAL TROLLEY		P O BOX 12127	PAROW VALLEY	7503	9315405
9491258	GROVER STEEL		P O BOX 75	BRACKENFELL	7561	9491629
5352607	HERITAGE CASTINGS	WP PARK	13 MAIL STREET	GOODWOOD	7460	545500
9487230	HI-FIRE		P O BOX 313	SANLAMHOF	7532	9489747
7976559	HOLDFAST MANUFACTURING PRODUCTS		P O BOX 14534	KENWYN	7790	7976418
7617703	HOME LEISURE		P O BOX 18846	WYNBERG	7824	
525015	HOWDEN AIR INDUSTRIES		P O BOX 185	PAARDEN EILAND	7420	526745
736874	JUST BLINDS		P O BOX 282	OTTERY	7808	736076
6923735	KATZ ENGINEERING		5 INDULAND AVENUE	LANSLOWNE	7780	6922715
9463880	KDM METAL FABRICATORS		P O BOX 666	SANLAMHOF	7532	9463811
9815641	KELBY CABINETS		P O BOX 73	SANLAMHOF	7532	
5110503	KRUPP & CO.		P O BOX 469	PAARDEN EILAND	7420	5117737
9311271	KUHN MACHINES		P O BOX 6412	PAROW EAST	7501	9313606
524153	LANCAL ENGINEERING		P O BOX 36943	CHEMPET	7442	
9053730	MACADAMS MANUFACTURING		P O BOX 199	BLACKHEATH	7581	9051514
921748	MAGNADOOR		P O BOX 21110	DE TIJGERPARK	7500	9304596
9332492	MARTIN NEETHLING OFFICE FURNITURE		P O BOX 1514	DURBANVILLE	7551	9332495
9340978	MECOLADDER		P O BOX 6288	PAROW EAST	7501	9340979
9332738	MOD LIGHTING MANUFACTURERS		P O BOX 279	SANLAMHOF	7532	9315292
7975080	MODEL FURNITURE MANUFACTURERS		P O BOX 137	OBSEVATORY	7935	
7013350	MODERN LIGHT FURNITURE		P O BOX 45	ST JAMES	7945	
5513681	MODWELD		P O BOX 36626	CHEMPET	7442	526361
9462057	NICO'S WIRE WORKS		P O BOX 420	KASSELVLEI	7533	9487567
471016	NOBLE CREATIONS		P O BOX 1442	DASSENBERG	7350	477859
5910511	NORTH'S GARGEN FURNITURE MANUFACTURERS		P O BOX 44	ELSIES RIVER	7480	5924293
9317201	NU-OFFICE FURNITURE		30 BRENTFORD STREET	BEACONVALE	7500	9317995
5514535	OFFICE COMPUTER FURNITURE		P O BOX 36957	CHEMPET	7442	
5513587	OFFICE FURNITURE BROKER	39 STELLA PARK	STELLA ROAD	MONTAGU GARDENS	7441	5514430
5115997	OFFICE FURNITURE FACTORY SHOP		115 VOORTREKKER ROAD	MAITLAND	7405	
7619042	OLIVIER'S ART METAL WORKS		CASTER ROAD	LANSLOWNE	7780	7619043
9464084	OLYMPIC UPHOLSTERY		P O BOX 233	SANLAMHOF	7532	9490666

739550	ORIENTAL ART WELDING WORKS		P O BOX 357	CONSTANTIA	7848	733500
5352750	OUTDOOR LIFESTYLES		P O BOX 179	EPPINDUST	7475	
475200	PALLUCCI LEATHER FURNITURE		P O BOX 405	SALT RIVER	7924	475294
5910943	PALMERS WROUGHT IRON		P O BOX 356	ELSIES RIVER	7480	5924394
471018	PARKER KNOLL		P O BOX 72	WOODSTOCK	7915	477859
474253	PENINSULA SHEET METAL WORKS		4 GREY STREET	WOODSTOCK	7925	471442
9032167	PETREANZE CREATIONS		P O BOX 154	KUILS RIVER	7579	9031969
242376	PIPEFINE INDUSTRIES		P O BOX 15440	VLAEBERG	8018	230321
5511634	PURE STEEL PRODUCTS		P O BOX 37047	CHEMPET	7442	5511635
9539834	QUICKFIX INDUSTRIAL DOORS		P O BOX 39770	WOLTEMADE	7445	5939346
4482424	RELIANCE UPHOLSTERY & FURNITURE		P O BOX 36	SALT RIVER	7924	
7974898	RENAISSANCE FURNITURE CONTRACTS		P O BOX 14916	KENWYN	7790	7615521
5107631	ROBERTS MANUFACTURING		64 GREEN STREET	MAITLAND	7405	5107630
9317255	SAN ENGINEERING		P O BOX 401	PAROW	7499	9311647
9346090	SHELCO SHELIVING		P O BOX 104	EPPINDUST	7475	9348206
9319246	STEEL & BRASS PRODUCTS		P O BOX 12120	PAROW VALLEY	7503	9319794
9308974	STEELDESIGNS	8 SANLAM BUSINESS PARK	J SIMONIS STREET	PAROW	7500	
4482305	STEELY STAN		37 MAIN ROAD	OBSERVATORY	7925	4482305
7013586	STERIANOS ENGINEERING	UNIT 12 CELIE PARK	CELIE ROAD	RETREAT	7945	
9312224	SUMMIT STEEL		P O BOX 12068	PAROW VALLEY	7503	9312581
5923177	SWISS STEEL		P O BOX 1798	DURBANVILLE	7551	5923114
7041620	TEFA STEEL PRODUCTS		P O BOX 14433	KENWYN	7790	732393
9306125	THE CANE & PINE CO.		267 VOORTREKKER ROAD	PAROW	7500	
9326411	TOM HEARN		P O BOX 141	ELSIES RIVER	7480	9329146
5925199	TRIPAX PAXCOR		P O BOX 691	GOODWOOD	7459	5925198
5116463	VENTAIR		30 LOWESTOFT STREET	PAARDEN EILAND	7405	5104402
9303119	WHIP FIRE PROTECTION		P O BOX 1580	BELLVILLE	7535	922637
479878	WOODWINDS CUSTOM FURNITURE		1 NAPLES STREET	OBSERVATORY	7925	
5316556	WOODWORLD		7 HAWKINS AVENUE	EPPING INDUSTRIA	7460	
5101173	WOODY'S INTERIORS		86 MARINE DRIVE	PAARDEN EILAND	7405	5101173
7013202	ZEST MANUFACTURING		P O BOX 236	STEENBERG	7947	7013225

**ACCUMULATION OF THE RESPONSE TO THE MULTI-CHOICE ITEM
QUESTIONS OF THE SURVEY QUESTIONNAIRE:**

University of Cape Town

Number of questionnaires sent out:	153
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Number of questionnaires returned due to incorrect address or company closure:	3
Number of unattempted questionnaires returned:	7
Number of completed questionnaires returned:	23

Cumulative response from date of sending:	
1st week	7
2nd week	18
After reminder card sent out	21
After follow-up phonecall (3-4weeks)	23

Number of completed questionnaire with respondents falling outside the limits of the boundary conditions:	6
Number of times boundary condition 1 exceeded/breached:	
Number of times boundary condition 2 exceeded/breached:	5
Number of times boundary condition 3 exceeded/breached:	
Number of times boundary condition 4 exceeded/breached:	
Number of times boundary condition 5 exceeded/breached:	5
Number of times boundary condition 6 exceeded/breached:	4
Number of times boundary condition 7 exceeded/breached:	

where:

Boundary Condition 1 breached if the main concern of the business is not manufacturing.

Boundary Condition 2 breached if the business is associated with or is a subsidiary of another business.

Boundary Condition 3 breached if manufacturing facility is outside of the Western Cape region.

Boundary Condition 4 breached if annual turnover is less than R150 000.00.

Boundary Condition 5 exceeded if there were more than an average of 70 persons employed in the production system of the business through 1996.

Boundary Condition 6 exceeded if there were more than an average of 10 persons employed in managing, administration and marketing of the business through 1995

Boundary Condition 7 breached if the production system of the business is mostly automated.

Number of completed questionnaire respondents falling within the boundaries of the conditions for research:	17
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Response Rate: 11.11

Number of respondents primarily concerned with manufacturing:	15
Number of respondents concerned with other business fields besides manufacturing: Importing, Wholesaling, Service Providing:	2

Number of respondents with:

less than 5 persons employed in the production system	2
between 5 & 15 persons employed in the production system:	10

Number of questionnaires sent out:	153
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Number of times boundary condition 1 exceeded/breached:	
Number of times boundary condition 2 exceeded/breached:	5
Number of times boundary condition 3 exceeded/breached:	
Number of times boundary condition 4 exceeded/breached:	
Number of times boundary condition 5 exceeded/breached:	5
Number of times boundary condition 6 exceeded/breached:	4
Number of times boundary condition 7 exceeded/breached:	

where:

Boundary Condition 1 breached if the main concern of the business is not manufacturing.

Boundary Condition 2 breached if the business is associated with or is a subsidiary of another business.

Boundary Condition 3 breached if manufacturing facility is outside of the Western Cape region.

Boundary Condition 4 breached if annual turnover is less than R150 000.00.

Boundary Condition 5 exceeded if there were more than an average of 70 persons employed in the production system of the business through 1996.

Boundary Condition 6 exceeded if there were more than an average of 10 persons employed in managing, administration and marketing of the business through 1995

Boundary Condition 7 breached if the production system of the business is mostly automated.

Number of completed questionnaire respondents falling within the boundaries of the conditions for research:	17
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Response Rate: 11.11

Number of respondents primarily concerned with manufacturing:	15
Number of respondents concerned with other business fields besides manufacturing: Importing, Wholesaling, Service Providing:	2

Number of respondents with:

less than 5 persons employed in the production system	2
between 5 & 15 persons employed in the production system:	10

between 15 & 40 persons employed in the production system:	3
between 40 & 70 persons employed in the production system:	2

Number of respondents with :

less than 3 persons employed in the management, administration and marketing functions of the business:	9
between 3 and 5 persons employed in the management, administration and marketing functions of the business:	6
between 5 and 10 persons employed in the management, administration and marketing functions of the business:	2

Number of respondents with:

only labour intensive operations in their production system:	12
mostly labour intensive operations with some automated operations.	4
mostly automated operations with some labour intensive operations.	
only automated operations.	
invalid response	1

Number of respondents with:

job type production process flow	
batch type production process flow:	3
a combination of batch and job type production process flow:	14

Number of respondents who were:

Business owner and production manager	A	5
Partner or business part-owner and production manager	B	4
Production manager	C	3
Production supervisor or Forman	D	
Other	E	
Partner or part-owner and assistant production manager	F	1
Unknown	G	4

Number of respondents (according to position) covering the following tasks:

	A	B	C	D	E	F
production planning and scheduling	6	4	2			
supervising production	6	4	1			
purchasing materials, equipment and consumables	6	4	2			1
reviewing production performance	5	4	2			1
production system administration	3	3	2			
general business administration	4	1	1			1
personnel management	4	3	1			1

debt collecting	1		1			1
new product research and development	5	4				
new production methods research and development	4	4	1			1
sales and marketing	4	3	1			1
setting up machinery and equipment	3	3				
physical production tasks (welding, cutting, assembly, etc.)	3	2	1			1
maintenance of machinery and equipment	5	3	1			1
other tasks		3				

Number of respondents with their production system laid out:

with similar equipment/operations grouped together	9
with workcenters arranged according the progressive steps by which the products are made <u>with</u> backtracking of work through the process.	6
with workcenters arranged according the progressive steps by which the products are made <u>without</u> backtracking of work through the process.	1
with dissimilar equipment/operations grouped in workcenters to work on products with similar shapes and processing requirements.	1
with layout arranged according to the space available in the production facility.	1
with production layout arranged in another way.	

Number of respondents with:

only specialised production equipment and machinery.	
mostly specialised production equipment and machinery with some general purpose equipment and machinery	2
mostly general purpose production equipment and machinery with some specialised equipment and machinery.	12
only general purpose production equipment and machinery.	3

Number of respondents who determine the production batch size:

as the same as the order size.	6	A
as the order size plus stock items to gain better efficiencies by improving economic order quantities.	6	B
by scheduling all operations for maximum capacity - keep workers busy all the time.	2	C
by scheduling all operations to obtain balanced flow of work trough production system - no build up of WIP except through of bottlenecks.	1	D
by scheduling all operations according to the material in stock	1	E
unknown/invalid answer	1	F

Number of respondents with a production system where:

material & parts of each batch are kept together and only move to from one operation to the next when all the entire batch has been processed.

TB=PB

material & parts that have been processed by an operation move to the next even if the other parts & material in that batch have not been processed yet.

TB<PB

material & parts flow from one operation to another in another way.

	A	B	C	D	E	F
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TB=PB	3	4	1		1	
TB<PB	2	3	1	1		

On a scale of 1 to 5, 1 being only skilled and 5 only unskilled,

The number of respondents who rated the skill content of their production workforce as:

1	1
2	3
3	3
4	10
5	

where:

skilled employee = artisan

unskilled employee = labourer

On a scale of 1 to 5, 1 being minor and 5 major,

The number of respondents who rated the extent of the workers influence over their working environment as:

1	2
2	3
3	8
4	4
5	

Number of respondents remunerating production employees with:

salary or wages only	12
salary or wages as well as with financial incentives.	4
salary or wages as well as with non-financial incentives.	1
incentive scheme only.	

Number of respondents who have clearly stated and set quality standards for goods produced in their production system.	14
Number of respondents who do not have clearly stated and set quality standards for goods produced in their production system.	3

Number respondents with a product return rate of:

less than 1%	12
between 1% & 5%	5
between 5% & 15%	
more than 15%	

Number of respondents who did not know the defective/substandard product return rate.	
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where: defective product return rate = sum of products shipped / sum of the products returned due to being defective or of substandard quality.

On a scale of 1 to 5, 1 being consistently above standard and 5 consistently below standard,

The number of respondents who rated the quality of the products produced in their production systems as:

1	4
2	11
3	1
4	1
5	

Number of respondents who have one or more of the following person/persons responsible for checking the quality of parts or products produced in their production system.

Quality controller	
Forman/Production supervisor	3
Production manager	14
The workers themselves	7
Nobody	
Someone else	
unknown	1

Number of respondents with a production system where defects :

are most often noticed before processing begins	4	
are most often noticed near the start of processing	3	
are most often noticed about midway through processing	2	
are most often noticed near the end of processing	5	
are most often noticed once processing is complete or as goods are being prepared for dispatch.	3	
are noticed at varying stages of processing.	4	
cannot be traced to one particular stage in processing.	1	

Number of respondents who have clearly defined standard work methods & procedures for:

all the operation in the production process.	11
some of the operations in the production process.	5
none of the operations in the production process.	1

On a scale of 1 to 5, 1 being always late and 5 always on time,

The number of respondents who rated the due-date performance of their production systems deliveries as:

1	1
2	
3	6

4	7
5	2

Number of respondents with an weekly average absenteeism rate of:

less than 2%	6
between 2% and 5%	2
between 5% and 10%	8
more than 10%	1

where absenteeism rate = total weekly production hours available/hours lost due to absent workers

On a scale of 1 to 5, 1 being low and 5 high,

The number of respondents who rated the morale of their production workforce as:

1	
2	
3	1
4	11
5	5

On a scale of 1 to 5, 1 being poor and 5 excellent,

The number of respondents who rated the discipline of their workforce as:

1	
2	2
3	3
4	10
5	2

where discipline = attitude towards work & management, punctuality for work and adherence to instructions and company rules.

Number of respondents with production employee turnover through 1996 of:

less than 5%	8
between 5% and 15%	3
between 15% and 50%	3
between 50% and 100%	1
more than 100%	2
did not know	

where production employee turnover = total number of employees/number of employees turned over

Number of respondents with production employees turned over due to:

dismissal	6
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retrenchment	3
retirement	
resignation	9
absconding	4
contract expiry	1
other reason	1

On a scale of 1 to 5, 1 being never achieved and 5 always achieved,

The number of respondents who rated the expected productivity achieved by their production workforce as:

1	
2	
3	6
4	10
5	1

Number of respondents who blamed low productivity levels on:

low morale of the workforce	1
lack of skill and understanding of the job	2
lack of motivation	4
lack of effective training	3
workers disregarding set standard work methods and procedures	4
the lack of effective communication between management and workers	3
insufficient supervision	3
other factors.	1

On a scale of 1 to 5, 1 being untidy and 5 tidy,

The number of respondents who rated the cleanliness of their factory as:

1	
2	3
3	3
4	3
5	1
unknown	7

where:

untidy = blocked passageways, disorganised storage, cigarette butts, scraps of paper and tools scattered around the factory floor

tidy = clear passageways, clean floors, machines and equipment, tools in visible and easily accessible racks

The number of respondents who believed the cause of untidiness in their factory to be:

lack of formal floor organisation	4
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lack of effective training	1
worker laziness	2
disregard for instructions or standard procedures	4
lack of effective communication between management and workers	
not enough time to clean the factory	3
no definite place for tools and or parts	3
did not know	
other reason	

Number of respondents with a production system where material and workflow

is disrupted by WIP waiting to be processed and finished goods in storage.	4
is not disrupted by WIP waiting to be processed and finished goods in storage	13

Number of respondents with a production system where parts, material, wip and finished goods

are stolen, damaged and or misplaced before, between and after processing.	5
are not stolen, damaged and or misplaced before, between and after processing.	12

Number of respondents with a production system where parts and material

are always ready for processing when required.	7
are not always ready for processing when required.	10

Number of respondents with a production system where parts, material and goods are always being expedited:

to ensure all the workers are busy working all the time	5
to replace stolen, damaged or misplaced parts and goods	1
to complete late or urgent orders	12
for another reason	

Number of respondents with a production system where:

the same operations constantly slow the entire production process	3
the operation that slows the production process changes from one workcenter to another	9
the operation that slows the production process cannot be pinpointed	
no bottleneck operations exist.	5

Number of respondents with machine and equipment breakdowns caused by:

lack of effective routine maintenance.	7
users inadequate training	
users disregard for instructions or negligence.	3
old age and poor condition of machinery and equipment.	8

other problems.	
not a problems.	6

On a scale of 1 to 5, 1 being poor and 5 excellent,

The number of respondents who rated the on time delivery from suppliers as

1	
2	4
3	7
4	5
5	1

On a scale of 1 to 5, 1 being poor and 5 excellent,

The number of respondents who rated the quality of parts, material and goods received from their suppliers as:

1	
2	
3	3
4	12
5	2

On a scale of 1 to 5, 1 being poor and 5 excellent,

The number of respondents who rated the general attitude of their suppliers towards their business as:

1	
2	1
3	7
4	6
5	3